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ELEMENTS OF CHEMISTRY,

AND

NATURAL HISTORY.

TO WHICH IS PREFIXED

THE PHILOSOPHY OF CHEMISTRY.

BY A. F. FOURCROY.

TRANSLATED FROM THE FOURTH AND LAST EDITION OF THE ORIGINAL FRENCH WORK,

BY R. HERON.

IN FOUR VOLUMES.

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ELEMENTS

OF

NATURAL HISTORY

AND

CHEMISTRY.

PART II.

THE MINERAL KINGDOM: MINERALOGY.

CHAP. IV.

Genus II. *Imperfect Neutral Salts, with a Base of Ammoniac, or Ammoniacal Salts.*

AMMONIACAL salts are formed by the combination of an acid with volatile alkali, or ammoniac. Their taste is generally urinous: all of them are more or less volatile, and easier of decomposition than perfect neutral salts. We are acquainted with six kinds or species of ammoniacal salts:—ammoniacal sulphate; ammoniacal nitrate; ammoniacal muriate, or sal ammoniac properly so called; ammoniacal borate; ammoniacal fluate; and ammoniacal carbonate.

Species I. *Ammoniacal Sulphate.*

Ammoniacal ſulphate, formerly called *ammoniacal vitriolic ſalt*, or *ammoniacal vitriol*, reſults from a ſaturated combination of the ſulphuric acid with ammoniac. It is called *ſecret ammoniacal ſalt of Glauber*, becauſe this chemiſt was the firſt who diſcovered it.

This ſalt, when very pure, appears under the form of needles, which when carefully examined are found to be flattened priſms of ſix faces, two of them very large, and terminating in ſix-ſided pyramids more or leſs irregular: but this form varies almoſt always either more or leſs from what we have deſcribed. Sometimes this ſalt appears in quadrangular priſms; and I have often obtained it in very thin ſquare plates. Its form, as in other inſtances of cryſtallization, ſeems to depend on the manner in which the cryſtalline laminæ are depoſited; which is either on their largeſt faces, their edges, or their angles.

The taſte of this ſalt is bitter and urinous; it is pretty light, and very friable.

As it contains, in cryſtals, a good deal of water, even a moderate fire inſtantly liquefies it; but it becomes gradually dry, in proportion as the water which it contained is evaporated. When brought to this ſtate, it melts, according to M. Bucquet, as it begins to become red-hot, without volatilizing; but M. Baumé ſays that it is partly volatile. On repeating this experiment, I obſerved that part of this ſalt is actually ſublimated, but part remains fixed in the veſſels. M. Bucquet is certainly to be underſtood as ſpeaking of this laſt part.

Ammoniacal

Ammoniacal ſulphate ſuffers ſcarce any alteration from air. It does not effloreſce like ſulphate of ſoda, but rather attracts moiſture.

It diſſolves very readily in water: two parts of cold water diſſolve one of this ſalt; and boiling water diſſolves a quantity equal to its own weight. It cryſtallizes by cooling; but the fineſt cryſtals which it affords are obtained by inſenſible and ſpontaneous evaporation. It combines alſo with ice, which it cauſes to melt with a conſiderable cold. It acts not at all on either aluminous or ſiliceous earth. Magneſia decompoſes it in part, eſpecially if time be allowed it to act, as Bergman has obſerved.

Quicklime, barytes, and the pure fixed alkalis diſengage the ammoniac from this ſalt; and we ſhall find the caſe to be the ſame with regard to ammoniacal muriate. When carbonate of potaſh or ſoda is diſtilled with ammoniacal ſulphate, a double decompoſition and combination take place. The ſulphuric acid combining with the fixed alkali, forms ſulphate of ſoda or potaſh, according to the nature of the alkali; and the carbonic acid which is diſengaged, being volatilized at the ſame time with the alkaline gas or ammoniac, theſe two bodies unite, forming a peculiar ammoniacal ſalt, which is cryſtallized in the receiver. We ſhall conſider this matter more at large under the hiſtory of Ammoniacal Muriate.

The nitric and the muriatic acids ſeparate part of the ſulphuric acid from ammonaical ſulphate; acting upon it juſt as upon ſulphate of potaſh and ſoda.

This ſalt has never yet been found among the products of nature. Yet M. Romé de Liſle, in his Eſſay

on Cryſtallography, 1772, page 57, informs us, that, in M. Sage's opinion, the ammoniac ſalt produced from volcanoes is of this kind. Art produces it by a direct combination of the ſulphuric acid with ammoniac, by decompoſing earthy or metallic ſalts with volatile alkali, or laſtly, by decompoſing nitric, muriatic, and carbonic ammoniacal ſalts with ſulphuric acid.

Ammoniacal ſulphate is applied to no uſe; though Glauber has recommended it ſtrongly for metallurgic operations.

Species II. *Ammoniacal Nitrate.*

AMMONIACAL nitrate, or *nitrous ammoniacal ſalt*, is, like the foregoing ſalt, a product of art. It is prepared by a direct combination of the nitric acid with ammoniac. Its cryſtals are priſms; but the number and the diſpoſition of their faces are not well known. M. Romé de Lille ſays, that it ſometimes cryſtallizes into beautiful needles pretty ſimilar to thoſe of ſulphate of potaſh. But its needles are long and ſtriated, and reſemble thoſe of common nitre much more than ſulphate of potaſh. The taſte of this ſalt is bitter, pungent, ſomewhat freſh and urinous. It is equally friable with ammoniacal ſulphate. It liqueſies when expoſed to the action of fire; exhales aqueous vapours, becomes dry, and long before being red-hot detonizes of itſelf, without being in contact with any combuſtible matter, and even in cloſe veſſels. In the firſt edition of this work it was obſerved, that this ſingular property appeared to depend on the ammoniac, becauſe the alkaline ga

ſeem

ſeems to have ſomething combuſtible in its nature, and increaſes before extinguiſhing the flame of a taper. M. Berthollet having expoſed a quantity of ammoniacal nitre to the action of fire in a diſtillatory and pneumato-chemical apparatus, and having obſerved the phænomena which it then exhibited with peculiar attention; diſcovered that it is not a true detonation which takes place on that occaſion, but a rapid decompoſition, by which part of the volatile alkali or ammoniac is entirely deſtroyed: the water obtained in the receiver contains a little nitric acid, proportioned to the quantity of the ammoniac decompoſed; and the latter gives out azotic gas, or atmoſpheric mephitis. On weighing the liquid product of this operation, the quantity of water is found to be greater than what the ammoniacal nitre was known to contain; and M. Berthollet thinks this increaſe of the water to be owing to the combination of the hydrogene of the ammoniac with the oxigene of the nitric acid. The azote, the other principle of this ſalt, which contains ſix parts of azote for one of hydrogene, eſcapes, and is collected under the glaſſes of the pneumatic-machine, in the form of azotic gas.

It is not known whether this ſalt be fuſible; for its firſt liquefaction is owing to the water of its cryſtallization, and it is diſſipated before it can undergo a ſecond.

We are equally ignorant with regard to its volatility: we can form no judgment of it; for, before it can be ſublimated, it ſwells and is decompoſed.

It feebly attracts the moiſture of the air; its cryſtals agglutinate, and form a kind of clods.

It diſſolves very readily in water; it combines with ice, and melts it, producing at the ſame time a conſiderable cold. It diſſolves more readily in warm than in cold water: not more than half a part of the former is requiſite to maintain it in ſolution, and it cryſtalizes by cooling, but irregularly. To obtain this ſalt in regular cryſtals, recourſe muſt be had to ſpontaneous or inſenſible evaporation.

Ammoniacal nitrate is decompoſed by bárytes, quicklime and the fixed alkalis, in the ſame manner as ammoniacal ſulphate. As the alkaline gas ſeparated by theſe cauſtic ſubſtances is very volatile and expanſive; ammoniacal nitrate, as well as the other neutral ſalts of the ſame genus, may be decompoſed cold by triturátion with quicklime. But when this decompoſition is attempted by fire in cloſe veſſels, the heat muſt be very cautiouſly managed, to prevent it from actual combuſtion.

The ſulphuric diſengages the nitric acid from this ſalt with effervéſcence, and combines with its baſe to form ammoniacal ſulphate.

Carbonate of potaſh or ſoda decompoſes it, and is in its turn decompoſed by it. In theſe operations, the ammoniac is ſublimated in a concrete form: the ſublimate we are afterwards to examine under the name of *ammoniacal carbonate.*

Ammoniacal nitre is not applied to any uſe.

Species III. *Ammoniacal Muriate,* or *Sal Ammoniac.*

Ammoniacal muriate, or the ſaturated combination of the muriatic acid with ammoniac, was called by the ancients

ancients *ſal ammoniac*; becauſe it was procured from Ammonia, a country in Libya, in which ſtood the temple of Jupiter Ammon.

This ſalt is found in places adjacent to volcanoes. It appears in the form of an efflorescence, or groups of needles, ſeparate, or compacted together, generally of a yellow or red colour, and mixed with arſenic and orpiment: but no uſe is made of that which is procured in this way. The *ſal ammoniac* employed in the arts, is prepared by a proceſs which we are about to deſcribe.

The real origin of this factitious ſalt was unknown till the beginning of the preſent century, tho' it had been made uſe of in many of the arts from time immemorial. M. Lemerie, conſul at Cairo, in a letter to the academy, dated 24th June 1719, firſt informed us how ſal ammoniac is obtained from the ſoot of camels dung, which is burnt at Cairo inſtead of wood.

This ſoot is put into large round bottles a foot and an half in diameter, and terminating in a neck two inches long. Theſe bottles are filled up with this matter to within four inches of the neck. Each bottle holds about forty pounds of ſoot, and affords nearly ſix pounds of ſalt. Theſe veſſels are put into a furnace in the form of an oven, ſo that only the necks appear above. A fire of camel's dung is kindled beneath it, and continued for three days and three nights. On the ſecond and the third day the ſalt is ſublimated. The bottles are then broken, and the ſalt taken out in cakes. Theſe cakes, which are ſent us juſt as they have been taken out of the bottles in Egypt, are convex, and unequal on the one ſide; on the middle of this ſide they exhibit, each a tubercle correſponding to the neck of the bot-

tle in which it was prepared. The lower ſide is concave; and both are ſooty.

Pomet makes mention of a *ſal ammoniac*, procured by the way of Holland, in truncated cakes reſembling ſugar loaves. Geoffroy, who was the firſt in France that diſcovered from what materials this ſalt is obtained, and who even gueſſed ſucceſsfully at the proceſs employed in Cairo for preparing it; found out that this ſecond ſpecies of *ſal ammoniac* comes from the Indies, where it is prepared in much greater quantities than in Egypt, by the ſame proceſs of ſublimation, but in a different form. Theſe Indian loaves conſiſt of fourteen or fifteen pounds each, are hollow at the bottom, and formed of various layers. The cone is truncated, becauſe its extremity, being impure, is always broken off.

M. Baumé has eſtabliſhed, in the neighbourhood of Paris, a manufactory of ammoniacal ſalt; in which this ſalt is compoſed, not extracted as in Egypt. M. Baumé's ſalt is likewiſe purer than the Egyptian.*

Ammoniacal muriate has a poignant, acrid, and urinous taſte. Its cryſtals are in the form of long hexahædral pyramids: a number of them are ſometimes united together in an acute angular direction, ſo as to exhibit

* In Britain ſal ammoniac is likewiſe prepared in great quantities. The volatile alkali is obtained from ſoot, bones, and other ſubſtances known to contain it. To this the vitriolic acid is added; and this vitriolic ammoniac is decompoſed by common ſalt by a double affinity. The liquor obtained in conſequence of this decompoſition contains ſulphate of ſoda and ſal ammoniac. The firſt is cryſtallized, and the ſecond ſublimated ſo as to form cakes, which are then expoſed to ſale. Lord Dundonald, by an ingenious proceſs, extracted ammoniac from pit-coal. H.

exhibit the form of feathers. M. Romé de Lille thinks the cryſtals of ammoniacal muriate to be octohædrons bundled together. This ſalt is ſometimes, but not frequently, found in cubic cryſtals in the middle of the concave hollow part of the ſublimated cakes.

This ſalt poſſeſſes one pretty ſingular phyſical property; a kind of ductility or elaſticity, which cauſes it to yield under the hammer, or even the fingers, and makes it difficult to reduce it to a powder.

Ammoniacal muriate is totally volatile; but a very ſtrong fire is requiſite to ſublimate it. This method is applied when it is wanted very pure and entirely free of water. It is reduced to powder, put into a matras, and the veſſel is then immerſed half way into a ſand-bath, where it is gradually heated for ſeveral hours. By this means we obtain a maſs conſiſting of ſtriated needles, joined to each other longitudinally. When this operation is properly conducted, very regular cubic cryſtals are often found in the midſt of the loaves. But if too ſtrong a heat have been applied, the product is only a ſhapeleſs thick and ſemi-tranſparent maſs, with the appearance of having been melted.

M. Baumé has obſerved, that by repeated ſublimations of this ſalt, a ſmall quantity both of ammoniac and of the muriatic acid is at length diſengaged; ſo that, according to that chemiſt, ammoniacal muriate might perhaps be decompoſed by continued ſublimation. This fact requires confirmation.

Ammoniacal muriate is liable to no alteration from air; it may be kept for a long time without ſuffering any change.

It diſſolves very readily in water. Six parts of cold water are ſufficient to diſſolve one of this ſalt. A conſiderable cold is produced as the ſolution takes place, and this cold is ſtill keener when the ſalt is mixed with ice. This artificial cold is happily applied to produce ſeveral phænomena which could not otherwiſe take place, ſuch as the congelation of water on certain occaſions, the cryſtallization of certain ſalts, the fixation and preſervation of certain liquids, naturally very ſubject to evaporation, &c.

Boiling water diſſolves a quantity of ammoniac, nearly equal to itſelf in weight. This ſalt may be cryſtallized by cooling; but, like other ſalts, it gives the moſt regular cryſtals by ſlow or ſpontaneous evaporation. A ſtrong ſolution of this ſalt, when incloſed in a flaſk, often depoſites at the end of a few days bundles of cryſtals, conſiſting of an horizontal thread, with others united to it in a perpendicular direction; and theſe again ſupporting others; ſo that the whole together diſplays a very natural imitation of vegetation. I have ſeveral times obſerved this phænomenon in my own laboratory*.

Aluminous

* Every chemiſt knows of what advantage it is to examine from time to time products preſerved in a laboratory, more eſpecially ſolutions of ſalts. When chance offers any curious facts to our obſervation, we ought always to note them down, that we may not loſe what may be afterwards found of high importance. Thus have I many times ſeen cryſtals formed which I could not obtain by evaporation. It happens too, that when phials are moved or uncorked, cryſtals are ſoon after depoſited; for motion and the contact of the air are highly favourable to the production of theſe. This note, though unneceſſary to thoſe who have been long employed in chemical purſuits, may be of uſe to thoſe who are juſt beginning to engage in ſuch ſtudies. F.

Aluminous earth does not decompoſe ammoniacal muriate. Magneſia decompoſes it, but with great difficulty, and only in part, as Bergman has obſeved. If a mixture of magneſia and a ſolution of ammoniacal muriate be put into a phial, at the end of a few hours, the celebrated chemiſt of Upſal has obſerved, there is diſengaged a quantity of ammoniacal vapours; but this phænomenon ſoon ceaſes, and but a very little of the ſalt is decompoſed.

Both lime and barytes ſeparate ammoniac from the muriatic acid even cold. The ammoniac gas is inſtantly volatilized, if this ſalt be but triturated with quick-lime; and its ſmell makes a lively impreſſion on the nerves. When this experiment is performed in cloſe veſſels, the ammoniac may be collected in water, either in a gaſeous ſtate or diſſolved. As no author has given a particular explanation of the method of performing this operation, though modern improvements have rendered it both accurate and certain, we think ourſelves obliged to give a full deſcription of it in this place.

A mixture of ſtrong quicklime and very dry ammoniacal muriate heated in a retort, with its extremity immerſed into a bell-glaſs full of mercury, affords a large quantity of alkaline gas or ammoniac. It is now known why ſcarce any product is obtained, and the operator is expoſed to danger from the breaking of the veſſels, when ſuch a mixture is diſtilled in balloons without a pneumato-chemical apparatus. Theſe circumſtances ariſe from the rarefaction of the mixture, and the quantity of the ammoniac gas diſengaged. M. Baumé, having himſelf experienced part of theſe inconveniences,

conveniences, gives it as his advice to put water into the retort. This fluid abſorbs and carries off part of the gas; but as the gas is much more volatile than water, a great part of it is always loſt. Chemiſts who are now acquainted with the ſtrong affinity between ammoniac gas and water, and with the amazing volatility of the gas, employ Mr Woulfe's apparatus very ſucceſsfully in performing this operation. This ingenious proceſs conſiſts in fitting to a balloon with two necks an empty bottle, and joining to it two or four collateral bottles connected by ſyphons. Quicklime and dry powdered ammoniacal muriate are put into a ſtone retort, which is luted to the balloon: a moderate heat is then cautiouſly applied till the bottom become red-hot, and even begin to vitrify. The ammoniac gas being diſengaged by the lime, paſſes into the balloon and the bottles, unites with the water with heat, and forms in the firſt bottles what is called *volatile ſpirit of alkali*, in the ſtrongeſt and moſt cauſtic ſtate in which it can poſſibly be obtained. By this means none of the ammoniac is loſt; and beſides the product is very white and pure, and the operator is in no danger from the vapour, or the burſting of the veſſels. Bucquet and I likewiſe found by a great many experiments, that one part and an half of lime, inſtead of three parts which are uſually employed, are ſufficient to decompoſe one part of ammoniacal muriate. Lime ſlaked by expoſure to the air decompoſes this ſalt as well as quicklime. The reſidue after this operation is calcareous muriate, which ſhall be hereafter examined. This proceſs proves lime to have a greater affinity than ammoniac with the muriatic acid.

The

The two fixed alkalis, as well as lime, decompoſe ammoniacal muriate, and diſengage the ammoniac in a pure gaſeous form. Theſe, as well as lime, may be made uſe of to ſeparate the alkaline ſpirit. But they are not uſually applied to this purpoſe in the laboratories; becauſe the uſe of them on this occaſion would render the proceſs much more expenſive, without affording any new advantage.

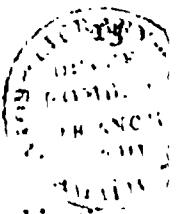
The ſulphuric and the nitric acids ſeparate the muriatic acid from this ſalt, and enter themſelves into combination with the ammoniac, with which they have a ſtronger affinity. The reſidues are ammoniacal ſulphate and nitrate.

Scarce any of the alkaline neutral ſalts acts upon ammoniacal muriate; none but thoſe which are formed by the combination of the carbonic acid with the two fixed alkalis, decompoſe it. A double decompoſition and combination take place on ſuch occaſions. In fact, while the muriatic acid unites with the fixed alkalis to form muriate of potaſh or of ſoda, the carbonic acid ſeparated from the alkalis, meeting with the ammoniac at the ſame time left in a ſeparate ſtate, forms ammoniacal carbonate, which is ſublimated and formed into cryſtals that are found ſcattered all over the inner ſides of the balloon. In performing this operation, one part of potaſh or ſoda, which muſt be very dry, is mixed with another of ſublimated ammoniacal muriate in powder. This mixture is put into a ſtone retort, to which a large balloon, or rather a glaſs cucurbite, muſt be fitted; and fire is now gradually applied till the bottom of the retort be made red-hot. A white ſalt in fine cryſtals paſſes by ſublimation into

the cucurbite, (which is ammoniacal carbonate). A little water paſſes at the ſame time, and the reſidue is muriate of potaſh, or of ſoda, according as the one or the other of thoſe fixed alkalis was employed. By this means we obtain a very conſiderable quantity of the ſalt, equal to no leſs than two-thirds of the ammoniacal muriate which entered into the mixture. This phænomenon induced Duhamel to think that a little fixed alkali eſcaped along with the volatile. It is eaſy to underſtand, ſince modern experiments have thrown light on this theory, that what gives on this occaſion ſo conſiderable a quantity of the ſublimated ſalt, is the union of the carbonic acid ſeparated from the fixed alkali, with the ammoniac. Till of late, however, this concrete volatile alkali was always thought to be the pureſt; and to it were aſcribed the properties of cryſtallizing and effervеſcing with alkalis; while that obtained by lime, which is pure volatile alkali, was thought to be a ſalt that had been altered, and in part decompoſed. From this we ſee what new light the diſcoveries of Dr Black have thrown on the nature of ſaline matters; and we cannot help ſaying, that they have rendered chemiſtry quite a new ſcience.

Ammoniacal muriate is applied to various purpoſes. In medicine it is adminiſtered internally as a diſcuſſive in obſtructions and intermittent fevers, &c. in doſes of a few grains. Externally applied, it is a powerful antiſeptic in gangrenous caſes, &c. &c.

It is uſed in many of the arts, more eſpecially in dyeing; and in metallurgy, when different metals are to be ſoldered together. Braziers uſe it to clear the ſurface of copper which they are to cover with tin.



Species IV. *Ammoniacal Borate.*

AMMONIACAL borate, or the ſaturated combination of the boracic acid with ammoniac, has not been yet examined by any chemiſt. I have made the following obſervations on ſome of its properties.

I diſſolved a quantity of very pure boracic acid in ammoniac, or cauſtic volatile alkali, till the ſubſtances appeared to be mutually and completely ſaturated: this ſolution I diluted in a little water, and then evaporated in a ſand-bath about one-half of this liquor. When cooled, it afforded a layer of cryſtals joined together, and exhibiting on their ſurface polyhædral pyramids. This ſalt has a poignant urinous taſte; it turns ſyrup of violets green, gradually loſes its cryſtalline form, and becomes brown by the contact of the air. It diſſolves readily enough in water. Lime diſengages the ammoniac.

Theſe are the chief properties which I obſerved on a firſt examination of it: but I have not yet made a ſufficient number of experiments upon it, to be fully acquainted with its nature.

Ammoniacal borate is not applied to any uſe.

Species V. *Ammoniacal Fluate.*

THIS ſalt, like the preceding, is ſcarce ſufficiently known, to be diſtinguiſhed by its peculiar properties from other ammoniacal ſalts.

M. Boullanger

M. Boullanger agrees with Scheele, that the fluoric acid when combined with ammoniac does not cryſtallize, but forms a jelly; which exhales vapours like thoſe of the muriatic acid, upon the addition of a portion of the ſulphuric. Neither of theſe chemiſts has examined the other properties of this ſalt; but they learned enough to enable them to diſtinguiſh between the fluoric and the muriatic acids.

Species VI. *Ammoniacal Carbonate.*

We give the name of *ammoniacal carbonate* to a kind of neutral ſalt, which was formerly called *concrete volatile alkali*, but is actually a neutral ſaline combination of the carbonic acid with ammoniac.

It does not exiſt in nature in a pure inſulated ſtate; but it may be obtained from almoſt any animal ſubſtance by the action of fire. It is likewiſe formed by the direct union of ammoniac with the carbonic acid, 1. By ſhaking that alkali in the upper part of a veſſel containing fermenting liquor. 2. By cauſing the carbonic acid to paſs into volatile ſpirit of alkali. 3. By pouring this acid into a veſſel, the ſides of which are wet with ammoniac diluted in water. 4. By a direct combination of carbonic acid gas with ammoniac gas above mercury; the two gaſeous ſubſtances inſtantly unite, a ſtrong heat is excited, and a concrete ſalt is formed on the ſides of the glaſs in which the mixture is made up. In all of theſe caſes ammoniacal carbonate is inſtantly formed in cryſtals. The ſame ſalt is likewiſe obtained by decompoſing ammoniacal muriate

with

with carbonic neutral ſalts having a baſe of potaſh or oda.

Ammoniacal carbonate may be made to aſſume a regular form. Its cryſtals appear to be prisms with a number of ſides. Bergman calls them *Octohædrons* with four of their angles truncated. M. Romé de Lille mentions his having ſeen this ſalt in groupes of ſmall tetrahædral ſummit.

Its taſte is urinous, but much weaker than that of pure cauſtic ammoniac; its ſmell, though not unlike that of ammoniac, is alſo much fainter; it communicates a green colour to ſyrup of violets. It may here be proper to obſerve with reſpect to the laſt-mentioned property, that the carbonic is not the only acid which does not abſolutely deſtroy the characters of ſuch alkalis as it is combined with; and that there is no reaſon on this account to refuſe the name of neutral ſalts to alkalis ſaturated with this weak acid; for their alkaline properties are in a great meaſure taken away; their acridity and cauſticity are entirely deſtroyed: and they no longer act with corroſive power upon animal matters.

Ammoniacal carbonate is very volatile, the leaſt heat being ſufficient to ſublimate it entirely. If regularly cryſtallized, it begins to liquefy when heated, with the help of the water to which it owes its cryſtalline form. But it is volatilized nearly at the ſame time; which renders it almoſt impoſſible to obtain this ſalt very dry and regularly cryſtallized.

It diſſolves very readily in water, producing cold at the inſtant of its ſolution, like all other cryſtallizing neutral ſalts. This property alone, plainly diſtinguiſhing it from pure ammoniac, which on the contrary

produces a conſiderable heat when it combines with water, might be ſufficient to claſs ammoniacal carbonate among the neutral ſalts. Two parts of cold water diſſolve rather more than one of this ſalt; warm water diſſolves more than a quantity equal to itſelf in weight. But, as the heat of boiling water diſſipates it, we cannot adopt this method of cryſtallizing it, without running the riſk of loſing a conſiderable part.

It becomes ſomewhat moiſt when expoſed to the air, and is the more liable to this when not entirely ſaturated with the carbonic acid.

Neither ſiliceous nor aluminous earth acts upon it any more than on the other neutral ammonical ſalts. Magneſia decompoſes it but very feebly. Lime has a ſtronger affinity than ammoniac with the acid, and decompoſes this as well as other ammoniacal neutral ſalts. Lime-water poured upon a ſolution of the ammoniacal carbonate, immediately gives a precipitate, and a ſtrong ſmell of cauſtic ammoniac is at the ſame time diffuſed around. The lime ſeizing the carbonic acid, forms with it chalk or calcareous carbonate, which is precipitated, and the ammoniac is ſeparated. Quicklime, triturated with ammoniacal carbonate, inſtantly diſengages the ammoniac in a gaſeous form. Cauſtic ammoniac may be obtained from this mixture by putting it into a retort accommodated with Woulfe's apparatus, juſt as the volatile alkali is obtained from ammoniacal muriate diſtilled in the ſame manner. This decompoſition proves lime to have a greater affinity than ammoniac with the carbonic acid, as well as with the other acids.

The

The fixed alkalis decompoſe ammoniacal carbonate as well as lime, by ſeparating the pure ammoniac, and combining with its acid.

Laſtly, the ſulphuric, the nitric, the muriatic, and the fluoric acids, have more affinity with ammoniac than the carbonic acid. When any of theſe acids is poured on ammoniacal carbonate, it produces a lively effervescence by diſengaging the carbonic acid. If this decompoſition be performed in a long ſtrait veſſel, certain evidence may be obtained of the preſence of the carbonic acid, by immerſing into it a taper, which is inſtantly extinguiſhed,—tincture of turnſol, which aſſumes a red colour,—or lime-water, which gives a precipitate. Theſe decompoſitions of ammoniacal carbonate by lime and the fixed alkalis,—which by ſeizing the acid, ſeparate the ammoniac; and by the acids,—which by uniting with the alkali, diſengage the carbonic acid; ſhow clearly the peculiar nature of ammoniacal carbonate. Bergman found by accurate experiments, that a quintal of this ſalt in cryſtals contains forty-five parts of carbonic acid, forty of ammoniac, and twelve of water. As this ſalt contains more of the acid than carbonate of ſoda, and carbonate of ſoda more than carbonate of potaſh, that ingenious chemiſt concludes that the weaker the alkaline baſe, ſo much the more acid is requiſite to ſaturate it. The boracic acid when cold does not decompoſe ammoniacal carbonate cold; but when a hot ſolution of the boracic acid is poured on this ſalt, a very diſcernible effervescence is produced. The carbonic acid then diſengaged may be collected by the uſual means; and what is found at the bottom of the veſſel is genuine ammoniacal borate.

This experiment, which I have often repeated, confirms Bergman's obſervation, that heat modifies or changes the laws of elective attraction.

Ammoniacal carbonate does not act on perfect neutral ſalts. But we ſhall hereafter ſee that it decompoſes calcareous neutral ſalts by the way of double affinity, which pure cauſtic ammoniac does not. This beautiful diſcovery of Black's explains the reaſon of what the chemiſts had long aſſerted, that ammoniac has a greater affinity than calcareous earth with the acids.

Ammoniacal carbonate is uſed in medicine as a ſudorific, an anti-hiſteric, &c. It is mixed with ſome aromatic matters. It has been conſidered almoſt as a ſpecific in the caſe of a viper's bite; but the Abbé Fontana with good reaſon oppoſes that notion. Many have adviſed the uſe of ammoniacal carbonate or concrete volatile alkali in venereal complaints; but experience has not yet determined certainly how far it is uſeful in ſuch caſes. All that we know concerning the application of this ſalt in the medical art is, that it is purgative, inciſive, diuretic, diaphoretic, and diſcuſſive; and that it acts powerfully in all diſtempers ariſing from the thickening of the lymph, ſuch as venereal miſfortunes, coagulations of milk, ſcrophulous ſwellings, &c.

It is given in doſes of a few grains in certain drinks, or in pills mixed with opium.

CHAP.

CHAP. VII.

Genus III. *Calcerous Neutral Salts.*

Species I. *Sulphate of Lime, Selenite, or Gypſum.*

THE combination of the ſulphuric acid with lime is properly *calcareous ſulphate*, but is commonly known by the name of *ſelenite, plaſter*, or *gypſum*. This ſalt abounds in nature. It is often found in vaſt banks or layers; as for inſtance at Montmartre near Paris. At that place whole mountains are compoſed of ſtrata of ſelenite or plaſter, covered over with a kind of argillaceous marl, which is almoſt always found with it.

As this ſalt has but very little taſte, and is ſcarce ſoluble, naturaliſts have long conſidered it as a ſtony ſubſtance; and they have diſtinguiſhed it into many varieties, according to its various degrees of purity, and the various forms under which it appears. We ſhall mention the chief of theſe varities.

The Principal Varieties of Calcareous Sulphate.

1. Calcareous ſulphate, or ſelenite in rhomboidal plates.

It is tranſparent like ice; the pieces which are ſhown in cabinets of natural hiſtory are irregular; but they always ſplit into rhomboidal plates.

2. Cuneiform calcareous ſulphate or ſelenite; or in the form of arrow-heads.

It conſiſts of two ſcalene triangles joined in the middle, each of which, as M. de la Hire has obſerved, conſiſts of triangular plates. This ſtone is called *lapis ſpecularis*, or *talc of Montmartre*.

3. Calcareous ſulphate or ſelenite in decahædral rhomboids.

Of this kind is that found in the quarries of Paſſy.

4. Calcareous ſulphate or ſelenite in dechædral priſms.

This conſiſts of hexahædral priſms, terminating in dihædral pyramids, or in a concave angle. It is found in Switzerland, &c. It is very like the preceding variety.

5. Lenticular calcareous ſulphate, or ſelenite in cock's combs, from Montmartre.

Theſe are collections of ſmall lenticular cryſtals, diſpoſed obliquely one beſide another. They are formed by the union of the arrow-heads, of which we have ſpoken under the ſecond variety.

6. Silky or ſtriated calcareous ſulphate or ſelenite, ſilky gypſum of China.

It

It is found in Franche-Comté, Angoumois, &c. It is in the form of very fine prisms, bundled together, usually bright and glossy like satin. It is very difficult to distinguish in this the rhomboidal plates, which are observed in all the other varieties.

7. Calcareous sulphate, common gypsum, or plaster-stone.

This substance is of a greyish white colour, spangled with small sparkling crystals, which may be easily taken out with a knife. It is found in strata; and most of the mountains about Paris consist of it. We shall afterwards understand that this is not pure selenite, and does not make good plaster till after being mixed with another earthy salt.

8. Calcareous sulphate in the form of alabaster, or gypseous alabaster.

This is a sort of plaster-stone, harder, and apparently of an earlier formation than the last described; from which it differs only as being half transparent, and consisting of small layers, as is observed of stalactites. There is a great deal of it found at Langry near Paris. This is one of the whitest kinds, and is sometimes veined or spotted with yellow, grey, violet, or black spots.

9. Calcareous sulphate, selenite, common gypsum or gypseous alabaster, coloured, veined, spotted, clouded, and puncturated.

This mixture of colours shows the selenite to be contaminated with some extraneous colouring matter. The colours of this earthy salt are almost always occasioned by iron in various states.

Calcareous ſulphate is likewiſe found diſſolved in water, as for inſtance in the wells of Paris; but never pure, and always combined with ſome other earthy ſalt, having lime or magneſia for its baſe.

We have already mentioned that calcareous ſulphate was long taken by naturaliſts for a ſtony ſubſtance. They thought it could not be a ſalt, as being apparently inſipid and inſoluble; but it actually communicates a peculiar ſapidity to water,—which is very ſenſible in the ſtomach. Crude water, or water impregnated with ſelenite, affects the ſtomach with a certain cold and heavineſs. As to its ſolubility; the form, ſize, tranſparency, quantity, and ſtrata, of the cryſtals of calcareous ſulphate, in many places, and particularly all around Paris, ſhow plainly that it muſt have been once diſſolved in water, and afterwards depoſited by that fluid.*

Calcareous ſulphate, when expoſed to the action of fire, loſes the water of its cryſtals, and when ſuddenly expoſed to a ſtrong heat decrepitates: it then aſſumes a rough white appearance, and becomes very friable. Under this form it is called *fine plaſter*. When mixed with water, it admits of being wrought into a paſte, of which very white and beautiful ſtatues are caſt in moulds. But as this plaſter ſoon dries, retaining but very little water, the ſtatues are apt to break under the ſlighteſt blow. If the fire be continued after calcareous

* M. Chaptal ſeems to have evinced; that native gypſum is formed from vitriolic acid; obtained in nature, by the gradual decompoſition of pyrites, and then held in ſolution in water, till it be carried into contact with lime; with which it immediately enters into combination. H.

ous ſulphate is reduced to a white powder, it melts at length into a kind of glaſs. But to produce this effect, the moſt intenſe heat is requiſite, ſuch as that of porcelain furnaces, or the focus of a burning-glaſs. Meſſrs d'Arcet and Macquer accompliſhed the melting of calcareous ſulphate. M. Macquer has obſerved, that when cuneiform ſelenite is expoſed to the focus of a burning-glaſs, ſo as that the light may fall on its poliſhed ſurfaces, it only becomes white; but when its edges are expoſed, it inſtantly melts and boils. Bergman's blow-pipe, or a ſtream of vital air poured on a burning coal, likewiſe melts it.

Calcareous ſulphate becomes phoſphoric when laid on hot iron; and this property is common to all calcareous ſalts. We have ſeen that lime likewiſe diſplays it, when ſlaked.

Calcareous ſulphate ſuffers no very obſervable alteration from the action of air; yet when expoſed to the open atmoſphere, the ſparkling and poliſhed plates of this earthy neutral ſalt loſe their luſtre, aſſume the variegated colours of the rainbow, ſplit into laminæ, and at length waſte away. But theſe phænomena are owing to the joint influence of heat, water, and air.

Calcareous ſulphate diſſolves in water; though ſlowly and inſenſibly. According to the chemiſts of Dijon, about 500 parts of water are requiſite to diſſolve one of this earthy ſalt. Warm water diſſolves it not in a greater proportion. We cannot obtain, by evaporating this ſalt, cryſtals reſembling thoſe of nature; on ſuch occaſions, as the boiling liquor is gradually evaporated, ſmall ſcales or needles are precipitated. The ſcales or plates obtained by evaporating a ſolution of calcareous

ſulphate, are uſually ſparkling, and when narrowly examined appear to be formed of very fine needles joined longitudinally.

Barytes, having a greater affinity than lime with the ſulphuric acid, decompoſes calcareous ſulphate. If a ſolution of barytes be poured into water containing a portion of this ſalt, ſtriæ of barytic ſulphate are inſtantaneouſly formed.

The fixed alkalis likewiſe decompoſe this neutral ſalt. When cauſtic fixed alkali is poured into a ſolution of calcareous ſulphate, a white precipitate is produced in mucilaginous flakes, which are ſoon accumulated at the bottom of the veſſels, and eaſily diſtinguiſhed to be quicklime by various means, and eſpecially becauſe much water is requiſite to diſſolve them. If the ſupernatant liquor be evaporated, the reſidue after evaporation is ſulphate of potaſh or of ſoda, according as vegetable or mineral alkali was made uſe of on the occaſion.

As ammoniac has not ſo ſtrong an affinity as lime, with any of the acids, it is unable to decompoſe calcareous ſulphate when this ſalt is very pure, and the ammoniac made uſe of very cauſtic; but if water in which calcareous ſulphate is diſſolved, contain ſome other ſalt with a baſe of magneſia or aluminous earth, ſuch as, for inſtance, the wells at Paris, ammoniac effects a precipitation of it. To ſucceed in this experiment, we muſt diſſolve calcareous ſpar in pure ſulphuric acid, and dilute this ſulphate of lime in diſtilled water. Cauſtic ammoniac poured into ſuch a ſolution, or, what is ſtill better, ammoniac gas cauſed to paſs through it, produces no precipitate.

Carbonate

Carbonate of potaſh and calcareous ſulphate mutually decompoſe each other. When theſe ſubſtances are mixed, a double decompoſition and combination take place. The ſulphuric acid forſakes the lime, in order to form ſulphate of potaſh by uniting with the fixed alkali; and the carbonic acid being ſeparated from the potaſh combines with the lime to form calcareous carbonate, which is well known under the name of *chalk*.

Carbonate of ſoda likewiſe decompoſes calcareous ſulphate, and is decompoſed in its turn. Sulphate of ſoda is formed on this occaſion by the combination of the ſulphuric acid with the mineral alkali; and calcareous carbonate or chalk by the combination of the lime with the carbonic acid.

Ammoniacal carbonate decompoſes calcareous ſulphate by a double affinity. The ſulphuric acid tends to unite with the ammoniac; while the lime is attracted by the carbonic acid, with which it has a great affinity, and by combining with it forms a precipitate of chalk.

This decompoſition is very diſcernible; and Dr Black's diſcoveries have given a very ſatisfactory explanation of the cauſe by which it is produced. And if a mixture of the ſolution of calcareous ſulphate and cauſtic ammoniac be for ſome time expoſed to the air, though it were at firſt perfectly tranſparent, its ſurface ſoon appears clouded, in conſequence of the carbonic acid being precipitated from the atmoſphere, and giving riſe to a double affinity. The ſame phænomenon may be produced by cauſing a few bubbles of this gazeous acid to paſs into the liquid. As concrete vola-

tile

tile alkali, or ammoniacal carbonate, was formerly thought to be pure volatile alkali,— Geoffroy, believing that this alkali actually gave a precipitate from calcareous ſulphate, concluded it to have a greater affinity than lime with the ſulphuric acid.

Many combuſtible matters, with the help of heat, decompoſe calcareous ſulphate. Coal from vegetable ſubſtances, having a greater affinity than ſulphur with oxygen, robs the ſulphuric acid of this part of its compoſition. The carbonic acid is diſengaged on this occaſion; and the ſulphur ſeparated from the ſulphuric acid uniting with the lime, forms what is called *calcareous hepar* or *liver of lime*, to which we ſhall, in future, give the name of *ſulphure of lime*.

The varieties of cryſtallized calcareous ſulphate are carefully preſerved in collections of the ſpecimens of Natural Hiſtory. When calcined and wrought in water, it is uſed in caſting ſtatues, &c. Various handſome pieces of ornamental furniture are formed of gypſeous alabaſter, cut and poliſhed. Lagny affords fine blocks for this purpoſe.

Plaſter ſtone is one of the moſt uſeful matters in nature. It is a mixture of calcareous ſulphate and calcareous carbonate or chalk. When expoſed to the action of fire, the calcareous ſulphate loſes the water of its cryſtallization, and the carbonic acid. Burnt plaſter is therefore a mixture of quick lime and calcareous ſulphate without water. If water be poured on this ſubſtance, the lime eagerly abſorbs it, giving out heat. The fetid odour which is felt when burning plaſter is extinguiſhed, is occaſioned by the ſulphur produced by the decompoſition of the ſulphuric acid by the animal

mal or vegetable carbonaceous matters which are always found to exiſt in plaſter-ſtone. The ſulphur then ſeparated forms a kind of *ſulphure*, or liver of ſulphur, from which the diſagreeable ſmell proceeds. When the lime has abſorbed enough of water to make it a paſte, it includes a portion of calcareous ſulphate, which, attracting part of the water, cryſtallizes in the midſt of the paſte. The lime becoming gradually dry, acquires a ſolid conſiſtency, with the help of the cryſtals of calcareous ſulphate, and forms a kind of mortar which is called *plaſter*. From what has been here ſaid, it may be underſtood why plaſter muſt be burnt to a certain degree and no farther. When not ſufficiently burnt, it does not unite with the water, becauſe the lime is not quick enough; when too much burnt, the lime unites with the calcareous ſulphate to form an indifferent ſpecies of vitreous frit which cannot combine with the water; this is called *burnt plaſter*. It may be likewiſe underſtood, that the reaſon why plaſter loſes its qualities when expoſed to the air, is the gradual ſlaking of the lime. When calcined anew, it regains its original properties. Laſtly, it is eaſy to ſee why plaſter is preſerved unchanged in dry hot places, and why in damp ſituations it waſtes gradually away in ſcales or plates. In the laſt of theſe caſes, the calcareous ſulphate, which is ſoluble in water, gradually loſes its conſiſtency and cryſtalline form. It is this ſolubility that diſtinguiſhes plaſter from mortar, the ſandy baſe of which is proof againſt the attacks of water. Plaſter is on this account unfit for uſe in places containing water, ſuch as reſervoirs, and other works of a ſimilar

kind;

kind; nor does it retain its hardneſs in low or ſubterraneous places.

Species II. *Calcareous Nitrate.*

Calcareous nitrate, or the ſalt reſulting from the combination of the nitric acid with lime, is far from being ſo copious in nature as calcareous ſulphate or ſelenite. It is found only in ſuch places as afford alkaline nitre. It is formed on the ſides of the walls, in places inhabited by animals; it is found likewiſe in putrifying animal matters, and in ſome mineral waters. But as it diſſolves very readily, and even deliquiates; it is diſſolved as faſt as formed; and from this circumſtance, it exiſts in large quantities in mother-water of ſaltpetre.

When regularly cryſtallized by a proceſs which we are hereafter to deſcribe, it exhibits ſolid priſms of ſix faces, pretty much like nitrate of potaſh, and terminating in dihædral pyramids. It is but ſeldom obtained in ſo regular a ſhape, but uſually in ſmall needles, adhering together, and of an indeterminate form.

The taſte of this ſalt is bitter and diſagreeable, very different from that of calcareous ſulphate. It even taſtes ſomewhat freſh, like nitrate of potaſh.

It eaſily liqueſies in the fire, and becomes ſolid by cooling. If taken into a dark place, after being thus heated, it becomes luminous; and in this ſtate it is called Baldwin's phoſphorus, *Balduinus*. It exhibits the ſame phænomenon when put on a red iron. When thrown on burning coals, it liqueſies and detonizes ſlowly,

ſlowly, in proportions as it becomes dry. Calcareous nitrate, when long heated, loſes its acid, which is decompoſed by the action of heat. When this operation is performed in a retort, the extremity of which enters a bell-glaſs full of water, a product of vital air is obtained, and towards the end of the operation azote or nitrogene gas. The reſidue is lime, in combination with a certain quantity of nitrous acid, if only a moderate fire have been employed, and that for a ſhort time. But ſtrong quicklime may be obtained by this proceſs, if extreme violence of fire be applied and continued long enough to effect a total decompoſition of the nitrous acid. This decompoſition of the acid is preciſely the ſame with that which is effected by the diſtillation of nitre of potaſh, as we have ſhown in the hiſtory of that neutral ſalt.

Calcareous nitrate attracts very rapidly the moiſture of the atmoſphere. And it muſt therefore be kept in very cloſe veſſels when we wiſh to preſerve it in cryſtals; it even waſtes away very quickly if the mouths of the veſſels be too often unſtopped.

This ſalt diſſolves very readily in water. No more than two parts of this fluid, even cold, are requiſite to diſſolve one of calcareous nitrate: boiling water diſſolves a quantity more than equal to itſelf in weight. To obtain this ſalt in cryſtals, we muſt evaporate the ſolution, and when it acquires nearly the conſiſtency of ſyrup ſet it aſide in a cool place: it then forms very long priſmatic cryſtals, which are uſually bundled together in needles diverging from a common centre. When a ſolution of calcareous nitrate, not juſt ſo much evaporated as the laſt, is expoſed to a dry warm

temperature, it at length forms more regular priſms, like thoſe which were deſcribed at the beginning of this article.

Sand and clay decompoſe calcareous nitrate, and ſeparate the acid.

Barytes, according to Bergman, decompoſes this ſalt, as well as calcareous ſulphate: magneſia produces no ſenſible alteration on it. M. de Morveau has obſerved, that lime-water poured on a ſolution of calcareous nitrate produces a precipitate. He aſcribes this effect to the phlogiſton of the lime, which, in his opinion, has a greater affinity with the nitrous acid than with lime. Unluckily that chemiſt did not examine the nature of the precipitate, otherwiſe he muſt certainly have obtained ſome farther knowledge concerning the phænomena of this curious experiment. M. Baumé had before obſerved, that lime water precipitates a ſolution of calcareous ſpar in nitrous acid, but aſcribed the phænomenon to a ſmall portion of argillaceous earth contained in the ſpar. This effect muſt depend either on a little magneſia, or on the avidity with which calcareous nitre abſorbs the water from the lime.

The fixed alkalis attract the nitric acid from calcareous nitre, and by this means precipitate the lime. Pure ammoniac does not decompoſe this ſalt any more than ſulphate of lime and the other calcareous ſalts in general.

The ſulphuric diſengages the nitric acid from this ſalt with effervescence. The acid thus diſengaged may be obtained in a receiver in the ſame way as common nitre. The ſulphuric acid, when poured into

to a ſolution of calcareous nitrate, gives immediately a precipitate of ſulphate of lime, leaving the nitric acid free and ſeparate in the liquor. As yet ignorant in what manner the other [illegible] upon this ſalt.

Calcareous nitrate decompoſes ſulphate of alkaline neutral ſalts. The reſult of this decompoſition is ſulphate of lime and nitre of potaſh or ſoda. Ammoniacal ſulphate, too, when mixed with a ſolution of calcareous nitrate, gives ammoniacal nitrate and ſulphate of lime. The laſt of theſe ſalts being ſcarce ſoluble, is precipitated at the inſtant of the mixture; which eſtabliſhes the certainty of this double decompoſition beyond a doubt.

Carbonate of potaſh likewiſe diſſolves, and is in its turn diſſolved by, calcareous nitrate. This double decompoſition gives nitrate of potaſh, which remains diſſolved in the liquor; and chalk or calcareous carbonate, which is precipitated.

Carbonate of ſoda acts in the ſame manner on calcareous nitrate, giving nitrate of ſoda, which remains diſſolved in the water,—and calcareous carbonate or chalk, which is precipitated.

Ammoniacal carbonate likewiſe decompoſes this ſalt by double affinity. Ammoniacal nitrate and carbonate of lime are formed on this occaſion.

Sulphate of lime produces no alteration on calcareous nitrate; but when theſe two ſalts are found diſſolved in the ſame water, as the firſt is ſcarce ſoluble, and the ſecond diſſolves very readily, they may be ſeparated by cryſtallization. The ſulphate of lime is precipitated at the firſt, and the calcareous nitrate does

not cryſtallize till the liquor be greatly condenſed by cooling.

Calcareous nitrate is applied to no uſe. It might be uſed in medicine as a very active diſcuſſive; and ſome medical chemiſts relate their having uſed it with ſucceſs, though they were not much acquainted with its properties.

Species III. *Calcareous Muriate.*

Calcareous muriate, the ſalt formed by the combination of the muriatic acid with lime, which was formerly known by the improper name of *fixed ſal ammoniac*, *oil of lime*, &c. abounds wherever muriate of ſoda is found, more eſpecially in ſea-water, to which it communicates its acrid bitter taſte; which was formerly aſcribed to bitumen, ſuppoſed to be contained in the water. But it is never pure in that fluid, being always mixed with muriate of magneſia. In order to procure calcareous muriate very pure, we muſt make a direct combination of the muriatic acid with lime to the point of ſaturation.

This ſalt, when dry and ſolid, appears in priſms with four ſtriated faces, terminating in very ſharp-pointed pyramids. It has a ſaline and very diſagreeable bitter taſte. When expoſed to the action of a moderate fire, it liquefies by means of the water of its cryſtals, and becomes fixed by cooling. When expoſed to a ſtronger fire, it ſuffers ſcarce any alteration. M. Baumé has obſerved, that on this occaſion it does not loſe its acid. When put on a red ſhovel, it becomes luminous;

luminous; on which account it is called *Homberg's phoſphorus.*

That portion of calcareous muriate which remains in the retort after the decompoſition of ammoniacal muriate by lime, is called *fixed ſal ammoniac.* It melts into a kind of frit, of a light ſlate grey, without giving out any muriatic acid, even though expoſed to a degree of heat ſufficient to vitrify the ſurface of the retort. This frit gives fire with ſteel; and when rubbed in the dark with a piece of the ſame metal, gives out phoſphoric ſparks.

It is to be obſerved, that this ſaline reſidue uſually contains more lime than is requiſite for the ſaturation of the muriatic acid; becauſe more than the neceſſary quantity of lime is employed to decompoſe ammoniacal muriate. This reſidue, no doubt, owes its property of affording an hard vitreous frit to its containing an extraordinary quantity of lime; for otherwiſe the frit would ſurely at length acquire moiſture and ſuffer alteration when expoſed to the air. Calcareous muriate, when it contains no extraordinary portion of lime, never aſſumes that degree of hardneſs which diſtinguiſhes this reſidue, nor diſplays any phoſphoric powers.

Pure calcareous muriate, when expoſed to the air, rapidly attracts moiſture, and waſtes entirely away by deliquium. It muſt be kept in a well ſtopped veſſel when we wiſh to preſerve it in its cryſtalline form.

This ſalt diſſolves very readily in water; about a part and an half of the fluid being ſufficient to diſſolve one part of calcareous muriate. Warm water diſſolves a portion more than equal to itſelf in weight. If this

ſolution be evaporated till it acquire the conſiſtency of ſyrup, and then left to cool ſlowly, it cryſtallizes into tetrahædral priſms, ſeveral inches in length, and placed in the diſpoſition of radii, diverging from a common centre. We may obſerve, that this is almoſt invariably the form of all calcareous ſalts. When the liquor is too much evaporated, or too haſtily cooled, it becomes a ſhapeleſs maſs ſet with ſharp points on the ſurface.

A ſolution of calcareous muriate evaporated to 45 degrees of M. Beaumé's areometer, and then expoſed to cold in a bottle, depoſites very regular, and often very large, priſmatic cryſtals. Sometimes when this ſolution is ſhaken before being cryſtallized, it is ſuddenly formed into a very ſolid maſs; at which inſtant it gives out a great deal of heat.

Barytes, according to Bergman's experiments, having a greater affinity than lime with the muriatic acid, decompoſes calcareous muriate. Lime and magneſia produce no alteration on this ſalt.

The fixed alkalis precipitate the lime. If the two liquors be concentrated, the lime, abſorbing the ſmall portion of water which they contain, forms almoſt inſtantaneouſly a jelly which ſoon becomes quite ſolid. This experiment is called a *chemical miracle*; becauſe it exhibits two fluids paſſing ſuddenly into a ſolid ſtate. But it does not ſucceed well except with a ſolution of carbonate of potaſh and ſoda; for the pure cauſtic alkalis precipitate the lime in too divided a ſtate.

Cauſtic ammoniac does not decompoſe calcareous muriate; for it has not ſo great an affinity as lime with the muriatic acid: a fact which proves that ammoniacal

cal muriate may be completely decompoſed by this ſalino-terrene ſubſtance.

The ſulphuric and the nitric acids diſengage the muriatic acid from this ſalt with efferveſcence; and with a diſtillatory apparatus, the acid might be obtained from this ſalt in the ſame manner as from muriate of ſoda. The diſtillation of this earthy ſalt with the nitric acid gives the nitro-muriatic acid, or *aqua regia*, becauſe of the volatility of the two acids.

Calcareous muriate decompoſes ſulphate of potaſh or ſoda. The reader may obtain the fulleſt conviction of the truth of this fact by mixing ſolutions of theſe ſalts. A precipitate is immediately produced, which may be diſtinguiſhed to be ſulphate of lime. The incumbent liquor contains muriate of ſoda or potaſh, which may be obtained by evaporation; nay, even the taſte of the liquid is a proof of its exiſtence.

Carbonate of potaſh or ſoda likewiſe decompoſes calcareous muriate. Two decompoſitions and two combinations take place on ſuch occaſions. The muriatic acid contained in the latter ſalt, deſerting its baſe, combines with the potaſh or ſoda to form muriate of potaſh or ſoda, which remains diſſolved in the liquor; and the carbonic acid likewiſe forſaking the fixed alkalis and combining with the lime, forms a precipitate of chalk or calcareous carbonate. If the carbonate of potaſh or of ſoda be diſſolved in a very ſmall quantity of water, and the ſolution of calcareous muriate be at the ſame time concentrated, the mixture becomes thick and gelatinous. It then aſſumes greater conſiſtency, and hardens into a kind of factitious ſtone, if the two ſubſtances be juſtly proportioned in the compoſition.

poſition. The firſt chemiſts who obſerved this phænomenon called it *a chemical miracle.*

Ammoniacal carbonate decompoſes calcareous muriate by a double affinity, in the ſame manner as calcareous ſulphate and nitrate. The ammoniac combines with the muriatic acid, forming ammoniacal muriate, which remains diſſolved in the liquor; while the carbonic acid combining with the lime, forms calcareous carbonate, which is precipitated.

If calcareous muriate and calcareous nitrate be diſſolved together in water, it becomes very difficult to ſeparate them, becauſe they are both cryſtallized by the ſame laws. But calcareous muriate and calcareous ſulphate may be eaſily obtained ſeparate; for the laſt cryſtallizing only by evaporation, leaves the calcareous muriate pure, and it then cryſtallizes by cooling. This obſervation is of ſome importance; for theſe two ſalts are often found in ſolution in the ſame mineral water.

Calcareous muriate has not yet been applied to many purpoſes. It exiſts in a large proportion in the gabel-ſalt, recommended in ſcrophulous caſes as a purging diſcuſſive; and I have already obſerved that gabel-ſalt is indebted to it for part of its properties. I likewiſe obſerved that the ſtrong taſte of calcareous muriate, and its tendency to ſolution, give us reaſon to expect very happy effects from it in all diſtempers in which an alteration of the humours is requiſite. It is greatly to be wiſhed that phyſicians were acquainted with its properties, and would preſcribe it in many of thoſe caſes in which the uſual diſcuſſives are found not to act with ſufficient efficacy, eſpecially in inſtances when

when mercurial preparations cannot be ſafely adminiſtered. I have already given the reſult of all my experience concerning the nature of this diſcuſſive ſalt in a memoir inſerted among thoſe of the Royal Society of Medicine for the years 1782 and 1783.

Species IV. *Calcareous Borate.*

THIS name may be given to the combination of the ſedative or boracic acid with lime. This ſalt has never been examined, though it be certain that the boracic acid is capable of combining with lime, as lime decompoſes borax of ſoda. The chemiſts of the academy of Dijon have obſerved, that the concrete boracic acid, when treated in fire, with flaked lime, affords a matter whoſe parts adhere very feebly together, and take no hold on the crucible. If this matter be caſt into water, it diſplays none of the characteriſtics of lime; and this proves that a combination muſt actually have taken place. M. Baumé mentions his having ſaturated lime-water with ſedative ſalt: the liquor when evaporated in the air afforded no cryſtals, but yellowiſh pellicles, having a faint taſte of the boracic acid. Laſtly, the academicians of Dijon digeſted on a ſand-bath a ſaturated ſolution of this acid with flaked lime. This ſolution, when filtered, gave a copious white precipitate on the addition of fixed alkali. Theſe ſeveral experiments ſhow nothing more than the poſſibility of diſſolving lime by the boracic acid, and give us no information concerning the properties of

the neutral ſalt which reſults from the combination then effected.

Species V. *Fluor Spar, or Calcareous Fluate.*

This ſalt is a combination of the fluoric acid with lime. It abounds through nature. It is found more eſpecially in the neighbourhood of mines, the exiſtence of which it always indicates. Hitherto it has been conſidered as a ſtone, on account of its inſipidity, hardneſs, and inſolubility. It is called *ſpar*, as being of a ſpathoſe form and fracture; *fluor* or *fuſible*, becauſe it melts very readily, and is even employed advantageouſly as a flux in the working of mineral ores; *vitreous*, becauſe it has the appearance of glaſs, and may even be formed by fuſion into a very fine ſpecies of glaſs; *cubic*, becauſe it appears always under a cubic form; and *phoſphoric*, becauſe when heated and taken into a dark place it has a luminous appearance. Before Scheele's diſcovery of it, vitreous ſpar, though ſufficiently diſtinguiſhed by the miners from all other mineral matters, in conſequence of its fuſibility, had been always confounded by naturaliſts with gypſeous ſubſtances, calcareous and ponderous ſpars, which have been alſo called *fuſible*. The celebrated Margraaf, however, had eſtabliſhed a diſtinction between this ſalt and ponderous ſpar; appropriating to the former the name of *vitreous fuſible ſpar*, and calling the latter *phoſphoric fuſible ſpar*; and our acknowledgments are due to that chemiſt for the firſt diſcoveries of the properties of calcareous fluate.

This

This ſalt appears uſually under the form of very regular cubic cryſtals, of various colours, and of an icy and vitreous tranſparency. Its fracture is ſpathoſe, and exhibits cubical plates ſeemingly cracked at the ſurface. It breaks when ſtruck againſt ſteel: it is always found among mineral ores, to which it often ſerves as a bed or matrix. Sometimes it is opaque, and in irregular maſſes. It is weightier than any of the other ſaline matters which we have examined. It is ſometimes clouded, veined, ſpotted, and oftener green, red, roſe, or violet coloured, &c.

We may take notice of ten leading varieties of this ſalt as it is found in nature.

Varieties.

1. Cubic calcareous fluate, or vitreous ſpar, white and tranſparent.
2. Cubic calcareous fluate, or vitreous ſpar, white and opaque.
3. Cubic calcareous fluate, or vitreous ſpar, yellow; falſe topaz.
4. Cubic calcareous fluate, or vitreous ſpar, reddiſh; falſe ruby.
5. Cubic calcareous fluate, or vitreous ſpar, pale green; falſe aqua-marine.
6. Cubic calcareous fluate, or vitreous ſpar, green; falſe emerald.
7. Cubic calcareous fluate, or vitreous ſpar, violet; falſe amethyſt.
8. Octohædral calcareous fluate, or vitreous ſpar, with truncated pyramids.

I have

I have in my poſſeſſion a cryſtal of this kind, which is ſemi-tranſparent and ſomewhat blackiſh.

9. Calcareous fluate, or vitreous ſpar, in an irregular lamellated maſs.

It is almoſt always of a clear green or violet colour. It forms the *gangue* of ſeveral ores, and is ſometimes in rolls.

10. Calcareous fluate, or vitreous ſpar, in layers of various degrees of thickneſs and of various colours.

Almoſt all of theſe varieties of calcareous fluate are ſtill but one ſaline ſubſtance, namely a combination of the fluoric acid with lime. They are uſually found, however, when carefully analyſed, to contain various extraneous matters, ſuch as ſiliceous earth, clay, and iron. This is the character of all natural products in general. England is very rich in calcareous fluate.

When this earthy ſalt is expoſed to a moderate fire, it acquires a phoſphoric quality in a pretty eminent degree; but if made red hot, it is entirely diveſted of this quality. It at the ſame time loſes its green or violet colour, and becomes grey and friable. When ſuddenly expoſed to a ſtrong heat, it decrepitates almoſt in as lively a manner as muriate of ſoda. When powdered fluate of lime is thrown on a hot iron, it gives a bluiſh or violet light, which in an inſtant diſappears. If expoſed a ſecond time to heat, it no longer exhibits the ſame phænomenon.

A ſtrong heat melts this ſalt into a tranſparent uniform glaſs, which adheres to the crucibles. It melts

one

one fourth of its weight of fine quartz, and is therefore uſed as a flux in ſmelting.

Calcareous fluate is neither alterable by air nor ſoluble in water. It ſerves as a flux for earthy and ſalino-terrene matters. Pure fixed alkali, whether mineral or vegetable, does not decompoſe it; becauſe, according to Bergman, lime has a greater affinity than either of theſe ſalts with its acid.

The concentrated ſulphuric acid diſengages the fluoric acid from this ſalt, and is commonly employed for this purpoſe. One part of calcareous fluate in powder, together with three parts of ſulphuric acid, are put into a glaſs retort. This mixture becomes gradually hot, an effervescence is produced, and the fluoric acid is diſengaged in a vaporous form. This diſtillation is effected without the application of external heat; and a white ſubſtance, reſembling an efflorescence, is ſublimed and depoſited in the receiver by the acid gas. Heat being then applied, the fluoric acid is obtained in a concentrated ſtate, covered with a thick earthy pellicle, reſembling the white efflorescence above mentioned; and drops into water in the receiver. This acid may be obtained in a gazeous form, by inſerting the extremity of the retort into a bell glaſs filled with mercury. This aeriform acid is tranſparent, and never ſuffers the earth combined with it to be precipitated but when it comes into contact with water. From this we underſtand why the liquid fluoric acid depoſites ſtony incruſtations in the bottom of the receiver: for whenever it is combined with water it becomes incapable of maintaining them in ſolution. We have already taken notice that this earth, being of a ſiliceous nature, ſeems to have originally

originally belonged to the glaſs veſſels which have been corroded by the fluoric acid, and is not produced by the combination of the acid with water, as Scheele at firſt imagined. At the end of the diſtillation, the reſidue is obſerved to be hard, of a white or reddiſh colour, and diſpoſed in plates, while the retort is corroded in a very diſcernable manner. „This did not eſcape Margraaf's obſervation: and by examining the reſidue, we find it to conſiſt of calcareous ſulphate mixed with ſiliceous, or often even with aluminous earth, and a little magneſia. The two laſt of theſe ſubſtances, as well as iron, appear to exiſt only accidentally in calcareous fluate. The incruſtation depoſited by the fluoric acid is of a ſiliceous nature; for it is neither fuſible nor ſoluble in acids, and the fixed alkalis melt it into a white durable glaſs. It appears from the hiſtory of this experiment, that it is impoſſible to diſtil a great quantity of this acid. I have ſeveral times tried it with a pound of calcareous fluate, with a view to obtain a good quantity of the fluoric acid; but finding the retort always incapable of reſiſting ſo corroſive an agent, I was at length obliged to give up the hope of diſtilling ſo large a quantity

The nitric acid decompoſes calcareous fluate; but, according to M. Boullanger, the phænomena which appear on the occaſion are very different from those which we have juſt been deſcribing. No incruſtation is formed, as when the ſulphuric acid is employed to decompoſe this ſalt. But the circumſtances of this operation have not yet been examined with ſufficient attention.

According

According to Scheele, the muriatic acid likewiſe ſeparates the fluoric; but he gives no particular account of the phænomena attending this decompoſition.

We are as yet ignorant of the manner in which moſt of the neutral ſalts act on calcareous fluate. We know only that carbonate of potaſh or ſoda decompoſes it by a double affinity, whereas the cauſtic fixed alkalis never decompoſe it. When one part of this ſalt is melted with four parts of carbonate of potaſh, if the mixture be thrown, when melted, into water, it gives a precipitate of carbonate of lime, which is formed by the union of the carbonic acid with the lime of the calcareous fluate; and the liquor contains fluate of potaſh, which may be obtained by evaporation in a gelatinous form. When carbonate of ſoda is employed, the products are carbonate of lime and fluate of ſoda; and the laſt is obtained in cryſtals by evaporating the liquor.

Calcareous fluate is not employed for any other purpoſe but in ſmelting mineral ores; and it is an excellent flux. It might be uſed for the ſame purpoſe in aſſaying metals.

Species VI. *Carbonate of Lime or Chalk; Calcareous matters in general.*

Calcareous ſpar, marble, chalk, and all calcareous matters in general, are ſaline ſubſtances formed by the combination of the carbonic acid with lime: the proper denomination to be given them is therefore *carbonate of lime*, or *calcareous carbonate*. This ſubſtance has been

been ranked by naturaliſts among ſtones; becauſe they have not diſtinguiſhed it to poſſeſs any ſaline properties. We ſhall ſee, however, that it has a kind of ſapidity, is ſoluble in water, admits of decompoſition, and affords when analyſed a great quantity of the carbonic acid, and of the ſalino-terrene ſubſtance known by the name of *lime*. As calcareous ſpar is the laſt modification of a matter which exiſts under a vaſt variety of forms, and has paſſed through many different ſtates, before being regularly cryſtallized; it will therefore be proper to take a general view of calcareous or cretaceous ſubſtances *.

No department of natural hiſtory diſplays a wider field, or a fuller ſeries of well eſtabliſhed facts, than that of calcareous matters. Long and uniform obſervation, with proper opportunities of obſerving the gradual progreſs of nature in forming theſe bodies, has determined that the bottom of the ſea is the great laboratory in which the proceſſes neceſſary for their production are conſtantly carried on. Among the numerous

* I am of opinion, that all thoſe ſubſtances which are uſually known in natural hiſtory by the name of *calcareous*, might, with more propriety, be denominated *cretaceous* ſubſtances. The latter term indicates the neutral ſaline combination formed by lime and the carbonic acid, namely, chalk, *creta*; the former belongs properly to lime calx, which is the baſe of that ſalt. The expreſſion *calcareous earth*, or *matter*, ſhould be appropriated to quicklime; *chalky*, or *cretaceous matter*, ſhould be applied to the combination of quicklime with the acid of chalk. But it is not to be expected that theſe two expreſſions which have always been ſynonimous, ſhould be all at once adopted into our language, and applied to diſtinct ſubſtances, whatever might be the advantage ariſing from this uſe of them. F.

rous tribes of animals inhabiting that immenſe body of water, there are ſeveral claſſes, the numberleſs individuals of which appear to be deſtined to increaſe the ſolid maſs of our globe. Such are ſhell-fiſhes, madrepores, and lithophites; the ſolid parts of which when examined by the chemiſt ſome time after the death of the animal, exhibit all the characteriſtics of calcareous matters. Calcareous mountains are formed by the ſucceſſive accumulation of thoſe marine ſkeletons. Tho' there be a mighty difference between theſe animated beings in their natural ſtate, and cryſtallized calcareous ſpar; though it be difficult on a firſt view to perceive any reſemblance between the ſoft pulpy ſubſtance of the animal, and the hard ſtony maſs which its carcaſe afterwards contributes to form, and which is deſtined to cement and conſolidate our buildings; yet it is not impoſſible to form an idea of the ſucceſſive alterations which they muſt undergo before they can arrive at the ſtate of mineral bodies. The following appear to be the gradations through which this animated organized matter muſt paſs, before it can become tranſparent and cryſtalline carbonate of lime, or calcareous ſpar.

The waters of the ocean, agitated by laws of motion, which are ſtill unknown to us, gradually change their ſituation, and come to ocupy a new bed. They deſert one ſhore, and encroach upon another. M. Buffon, in his Theory of the Earth, gives full evidence of this fact. When the waters retire from a part of the bed which they have occupied, they leave uncovered the ſtrata which their various motions (of which this celebrated philoſopher has given ſo ingenious an account) have formed

formed by the ſucceſſive accumulation of the ſolid parts or ſkeletons of marine animals. Theſe layers are almoſt entirely compoſed of ſhells; which loſing by putrefaction the animal gluten, and with it their colours, the poliſh of their interior ſurface, and more eſpecially their conſiſtency, become friable and earthy, and paſs into the ſtate of foſſils. Hence the production of earths and ſtones containing ſhells.

Theſe ſtones are worn by the waters till they gradually loſe the organic form, become more and more friable, and are at length converted into that ſubſtance known by the name of *chalk*. When a ſhell-ſtone is ſo hard as to be ſuſceptible of poliſh, and the ſhells of which it conſiſts have retained their organization, ſo far as ſtill to diſplay different colours, it is called a *lumachello*. When the marks of organization are totally deſtroyed, if the ſtone be hard and ſuſceptible of poliſh, it is known by the name of *marble*. Water impregnated with chalk, depoſites it on all bodies over which it flows, ſo as to form *incruſtations*. When it filtrates through the arches of ſubterraneous cavities, it depoſites a white opaque matter formed into conical figures, conſiſting of concentric layers; which reſemble the bottoms of lamps, and are called *ſtalactites*. When theſe are accumulated in large maſſes, ſo as to fill up the caverns, and remain long under ground, they acquire a conſiderable degree of hardneſs, and obtain the name of alabaſter. Laſtly, When water impregnated with chalk, extremely fine and very much attenuated, penetrates ſlowly into ſtony cavities, and depoſites that ſubſtance as it were particle by particle; theſe minute bodies gradually unite their correſponding ſurfaces in

a ſymmetrical and regular manner, forming hard tranſparent cryſtals, reſembling thoſe of ſaline matters: which receive the name of *calcareous ſpars.* This is the laſt degree of attenuation to which chalk is liable, the ſtate in which it differs the moſt from its original character as part of an animal body, and bears the greateſt reſemblance to a real ſalt.

Theſe tranſitions of cretaceous matters, through ſo many different ſtates, the conſideration of which opens to the naturaliſt ſuch extenſive views of the antiquity of this globe, the alterations which it has undergone, and the range of the animal kingdom, out of which ſo conſiderable a part of its ſurface and exterior ſtrata is formed; theſe diſplay to the eyes of the chemiſt nothing more than one matter, a neutral ſalt, formed by the combination of lime with the carbonic acid. We ſhall proceed to conſider it under both theſe points of view.

§ 1. *Natural Hiſtory of Calcareous Subſtances* *.

BEFORE entering into a particular enumeration of calcareous matters, it may be proper to take a general view of their diſpoſition in the terreſtial globe. Theſe ſubſtances are diſpoſed in layers of a larger or a narrower

* Although we have already, in the hiſtory of earths and ſtones, given methodical diviſions of calcareous matters, which have been uſually ranked by naturaliſts under that claſs of natural bodies; yet we think it proper to give here a new arrangement of them founded on other conſiderations than thoſe which have directed naturaliſts in their labours on this ſubject. F.

narrower extent, in an horizontal or an inclined direction, and impreſſed with the moſt unequivocal marks of their having been expoſed to the action of a maſs of water. Theſe ſtrata compoſe whole mountains and hills, &c. and form a conſiderable part of the cruſt or ſhell of our globe. They afford demonſtration that our earth was once covered by the waters of the ocean, as they conſiſt of the exuviæ of its inhabitants. The waters filtrating through thoſe calcareous maſſes, carry off part of their ſubſtance, and convey it deeper into ſubterraneous cavities, under the different forms which we are to examine. The general characteriſtics which have been aſſigned them by naturaliſts, and which ſufficiently diſtinguiſh them, are taken from two remarkable properties which they poſſeſs; they never ſcintillate with ſteel, and they effervesce with acids. As theſe calcareous matters appear under ſo many varieties of form, it becomes abſolutely neceſſary to arrange them under ſeveral genera. We admit ſix genera of calcareous matters *.

Genus I. *Earths and Stones, compoſed of Shells.*

Theſe ſubſtances have been ranked among ſtones, as being apparently inſipid and inſoluble. But when analyzed, they are found to be actually ſaline, as well as all the following genera. They are known by their organic

* The reader may perhaps be ſurpriſed to meet with new generic diviſions in the hiſtory of a ſpecies of ſalt: but theſe genera relate not to natural hiſtory, and are to be referred only to the particular neutral ſalt which we are examining. E.

organic form; ſhells are often found in them unbroken: the ſtone is indeed nothing but an accumulation of theſe organized forms; and even the original colours of the ſhells ſometimes appear in it. Sometimes too they are found to contain animals belonging to ſpecies which are no longer known to exiſt in the ſeas; ſuch are ſeveral ſpecimens of the *cornu-ammonis*, and all the nautili. Again, in Europe, and even in France, we find foſſil ſhells belonging to ſpecies of animals which are not now known to exiſt any where but in America. Several naturaliſts have formed very extenſive arrangements of foſſil ſhells; but as they are the ſame with thoſe of the living animals, we will treat of them elſewhere. There are likewiſe foſſil remains of marine animal bodies, which cannot be referred to any known ſpecies of the preſent inhabitants of the ocean. Tho' we have no complete work on animal foſſils, and this department of natural hiſtory has not yet been examined with ſo much care and accuracy as mineralogy; yet we have deſcriptions of a great many of thoſe bodies, which ſufficiently prove that the ſeas have been once inhabited by ſpecies of animals which no longer exiſt.

When calcareous foſſil bodies appear to have belonged to animals of a known ſpecies, they are then diſtinguiſhed by a name referring to their origin, and uſually compounded of the name of the claſs of the animals to which they belong, with the addition of a word or ſyllable denoting their ſtate as ſtones; ſuch as *madreporites*, &c. But it is to be obſerved that human bones, and the bones of quadrupeds, birds, and fiſhes, which have been buried under ground, though they

be likewiſe known by the name of *foſſils*, are not of a cretaceous nature; they retain their character of calcareous phoſphate. And therefore ornitholithes, ichthyolithes, &c. are not to be ranked among cretaceous ſubſtances.

In deſcribing organic ſubſtances, the origin of which is unknown, names have been aſſigned them, derived from their particular forms: of this kind are the *lapides judaici*, thought by ſome to be the ſpeculæ of ſea hedge-hogs; the *lapides numiſmales*, or *St Peter's pence*, reſembling pieces of money, which appear to be ſmall cornua Ammonis, arranged one over another; *foſſil bezoar*, a kind of round maſs or concretion in concentric layers; *ludus Helmontii*, the ſpaces of which appear to have been formed by the drying and ſhrinkling of a ſoft earthy matter, and afterwards filled with calcareous earth; the *trochites*, *entrochi*, and *aſtroites*, which are produced from a zoophyte named *ſea-palm*; and *the piſolites*, *colites*, or *meconites*, which are thought to be petrified eggs of fiſhes or inſects, but of which the true origin is unknown.

To this genus of true calcareous ſtones, we likewiſe refer all petrified ſubſtances, to whatever animals they may have belonged; and natural hiſtory therefore enumerates here *gammarolites*, *cancrites*, *entomolites*, *amphibiolites*, *zoolites*, and *anthropolites*. But from the new diſcoveries concerning the nature of bones it appears, as we have already mentioned, that theſe matters are not to be conſidered as cretaceous. The ſame may be ſaid of *glaſſopetræ*, or *petrified ſhark's teeth*; *ivory*, or *foſſil unicorn*, which is produced from elephant's teeth; *turquoiſe*, or *bones of green and blue colours*; *toad ſtones*, the

the grey or yellowiſh hollow ſtones; which, according to M. Juſſieu, are the upper parts of the grinders of the Braſilian fiſh called *grondeur;* and *ſerpent's eyes*, which according to that naturaliſt belong to the inciſive teeth of the ſame fiſh.

After this detail of particulars, we may venture to reduce this genus to two ſpecies, comprehending all its varieties.

Species.

1. Entire foſſil ſhells.

   Theſe differ in colour, luſtre, hardneſs, &c. Under this ſpecies we include madrepores, and all calcareous habitations of polypi in the foſſil ſtate.

2. Falun, or cron.

Shells broken and reduced to earth. The ſoil of a part of Touraine, and of ſeveral of the other provinces of France, is entirely of this nature. Theſe earths are an excellent manure.

Genus II. *Calcareous Earths and Stones.*

These conſiſt of the matters of the former genus, attenuated, diſſolved, and afterwards depoſited by water. They are found in banks or ſtrata in the bowels of the earth. We follow M. Daubenton's diviſion of the ſpecies of this genus.

Species.

1. Compact calcareous earth; chalk.

This ſubſtance varies in colour and fineneſs of grain; it is applied to a great many domeſtic uſes.

2. Spongy calcareous earth; ſtone marrow.
3. Calcareous earth in powder; foſſil meal.
4. Calcareous earth of the conſiſtence of cream; lac lunæ.
5. Soft calcareous earth; tufa. This ſubſtance, as it dries, becomes hard and white.
6. Coarſe-grained calcareous ſtone. Arcueil-ſtone is a ſpecimen of this. It is found to contain half-broken ſhells.
7. Fine grained calcareous ſtone. The thunder-ſtone is a variety of this ſpecies.

It would be improper to enter here into a minute detail of the varieties of theſe earths and ſtones: but it may be naturally imagined that there are a great many depending upon difference of colours and hardneſs, and the various purpoſes to which they are applied; and that theſe varieties are diſtinguiſhed by different names. Almoſt all of them may be prepared as lime for the purpoſes of building, &c, &c.

Genus III. *Marble.*

Marbles differ from calcareous ſtones properly ſo called, as being conſiderably harder. Like theſe, however, they do not ſcintillate with ſteel; they effervefce with acids, and their fracture is granulated; but their grain is much finer and cloſer: their colours are more brilliant, and they take a finer poliſh. All the world knows

knows the application of marble in ſculpture, architecture, &c. It is uſed too in ſome countries for making lime.

Species.

1. Lumachello.

The Italians give this name to a ſpecies of marble formed by the agglutination of ſhells.

2. Breccia.

This is a ſpecies of marble conſiſting of ſmall round maſſes, united by a cement of the ſame nature.

3. Marble, properly ſo called.

This ſubſtance exhibits neither the ſhells of lumachello nor the round maſſes of breccias; it is irregularly ſpotted, and ſometimes round. M. Daubenton arranges marbles by the number and the combination of their colours, including under the ſame denomination both lumachellos and breccias.

1. Marble of ſix colours; ſpecimen, white, grey, green, yellow, red, and black; Wirtemberg marble.

2. Marble of two colours; ſpecimen, white, and grey; marble of Carara.

3. Marble of three colours; ſpecimen, grey, yellow, and black; lumachello.

4. Marble of four colours; ſpecimen, white, grey, yellow, red; brocatello of Spain.

5. Marble of five colours; ſpecimen, white, grey, yellow, red, black: breccia of Old Caſtile.

4. Figured marble.

It repreſents ruins, as in Florence marble; or herbs, as in Heſſian marble.

It is to be obſerved, that the colours of marble depend almoſt always on the iron intermixed among its grains. This ſubſtance, though ſuſceptible of a fine poliſh, is very porous; every body knows that it is eaſily ſpotted: and this property renders it fit for receiving delineations of coloured flowers, and for being ſtained with many different colours.

Marble is often mixed with fragments of an hard ſtone, ſuch as quartz and ſilex. The part which contains ſuch fragments gives fire with ſteel. I have often obſerved this of ſeveral kinds of black marble.

Genus IV. *Concretions.*

Concretions are irregularly formed by the ſlower or quicker diſpoſition of calcareous matter by water on the ſurface of ſome body. They are not diſpoſed in extenſive layers, but by fragments; at firſt in inſulated maſſes; which are at length united in one uniform cruſt.

Species

1. Incruſtations.

Waters impregnated with chalk depoſite it on the ſurfaces of all bodies over which they flow: and incruſtations may therefore be of all poſſible forms, correſponding to the forms of the bodies on which they are depoſited. Such are thoſe of

of the waters of Arcueil; ſuch too is the Oſteocolla, &c.

2. Stalactites.

Theſe are gradually depoſited by water in concentric layers, ſuſpended from the arches of caverns, &c. They vary in ſize, tranſparency, or opacity, grain, colour, and form. They are generally hollow and pyramidal. *Flos ferri* is the pureſt of all the ſubſtances of this kind. When they adhere to the ſides of ſubterraneous cavities, they receive the name of *congelations*; when depoſited on the floor, they are called *ſtalagmites*.

3. Alabaſter.

Alabaſter ſeems to be formed of the pureſt ſtalactites, after they have been long buried under ground. It is ſofter than marble; and when poliſhed, its ſurface appears fat and oily. It evidently conſiſts of layers diſpoſed in various directions. It is always more or leſs tranſparent, which diſtinguiſhes it from marbles; but there are ſome ſpars which it never equals in tranſparency. Alabaſter poſſeſſes likewiſe all the characteriſtics of calcareous ſtones. It is cut into vaſes and ſtatues. There are many varieties of it.

Varieties.

1. Oriental alabaſter. This is the hardeſt and moſt tranſparent.
2. Occidental alabaſter; not ſo fine and pure as the preceding.

3. Alabaſter

3. Alabaſter ſpotted with various colours.
4. Wavy alabaſter. This is called *agate alabaſter.*
5. Flowered alabaſter; exhibiting ſpecimens of herborization.

Genus V. *Calcareous Spar.*

Calcareous ſpar differs from the four preceding genera in its form, which is generally more regular; and in its fracture. It is compoſed of laminæ arranged one above another, which are very diſcernible when it is broken. It crumbles down when ſtruck with ſteel.

Species.

1. Opaque calcareous ſpar.

   This is white or variouſly coloured: and uſually appears in rhomboidal laminæ.

2. Rhomboidal tranſparent calcareous ſpar; Iceland cryſtal.

   It repreſents objects double. It is, in ſpecimens, often an artificial fragment.

3. Lenticular calcareous ſpar.

   This M. de Romé de Lille ſuppoſes to be a variety of the hexahædral priſmatic ſpar, terminating in two obtuſely triangular pyramids. But, it is, in truth, only the preceding variety, rounded at its ſolid angles.

4. Calcareous ſpar in priſms without pyramids.

   Theſe are truncated hexahædral priſms, with faces either equal or unequal, and having ſometimes

Varieties.

sometimes their angles cut in such a manner as to make them twelve-sided prisms: which circumstances give three varieties of this species.

5. Calcareous spar in prisms, terminating in two pyramids.

The varieties of this spar are pretty numerous. Some of them are hexahædral prisms, terminating in pyramids, which are also hexahædral, and either whole or truncated. Others display at the extremity of the hexahædral prisms trihædral pyramids, either whole or truncated, or with dihædral summits. Lastly, There are some in quadrangular prisms, terminating in dihædral summits. When regular, these have eighteen trapezoid faces.

6. Pyramidal calcareous spar; or having twelve triangular faces.

This is formed of one, or by the union of two pyramids, without any intervening prism. The hexahædral or triangular form of those pyramids, the inequality of their sides, and the frequent mutilation of their angles, distinguish them into a great many varieties*.

7. Calcareous

* The reader who wishes to be more particularly acquainted with the varieties of the spars, may consult Dr Hill's work intituled, *The History of Fossils, containing the History of Metals and Gems, &c. London*, 1748, *Folio, with copperplates*. M. Romé de Lille gives an extract from this work in the first edition of his Crystallography, page 131, *et seq.* p. 191, *et seq.* concerning calcareous spar and rock-crystals. He shows Dr Hill's method to be perplexed and defective, &c. E.

Varieties.

7. Calcareous ſpar in duodehædral figures.

This ſpar, reſembling a kind of granite or marcaſite, appears to conſiſt of two truncated pentagonal pyramids joined at their baſe.

8. Calcareous ſpar in ſtriæ.

This is a collection of long priſms, bundled up together, in figures of no determinate regularity. The Swediſh *lapis ſuillus* belong to this ſpecies.

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§ II. *Chemical Properties of Calcareous Carbonate.*

AS the chemical properties of bodies refer to their principles or combination, they ſhould be diſtinguiſhed by names expreſſive of their nature. The various calcareous matters which we have enumerated, are therefore to be confounded, when we ſpeak of them chemically under the general name of *Calcareous Carbonate.* Experiments for determining the properties of this earthy ſalt, ſhould be made either on the moſt tranſparent calcareous ſpar, or on pure white marble.

In order to analyze calcareous carbonate, we muſt firſt deſtroy its aggregation by reducing it to powder. In this form it is white and opaque. It has no very

ſenſible

ſenſible taſte; but when kept for ſome time in the mouth, it contracts the fibres of the palate and the tongue.

When this earthy ſalt is expoſed to the action of fire, it loſes its acid and the water of its cryſtals. If ſuddenly expoſed to a ſtrong heat, it decrepitates and loſes its tranſparency. By diſtilling it in a retort we obtain water and a conſiderable quantity of carbonic acid gas; but a ſtrong heat is requiſite to diſengage the gas. After undergoing this operation, the calcareous matter is reduced to the ſtate of quicklime: the ſalt may be formed again by combining the quicklime with the acid. Chalk, which differs from calcareous ſpar in no reſpect but in being leſs cohefive, and opaque, has been diſtilled by M. Jacquin. The Duke de Rochefoucauld having repeated this experiment with much care, has obſerved that part of the aeriform carbonic acid eſcapes through the ſtone retorts uſed in diſtilling this ſubſtance. Dr Prieſtley has fully eſtabliſhed this fact by a number of very accurate experiments. An iron retort, or the barrel of a gun, may be uſed on this occaſion; but a little inflammable gas or hydrogene is always obtained at the ſame time, and is produced by the action of water in the chalk on the iron.

When calcareous carbonate is expoſed to a ſtrong fire in clay crucibles, it melts into glaſs round the ſides of the veſſel. M. d'Arcet has melted pieces of ſeveral ſpecies into a ſpotted tranſparent glaſs. But as Macquer has obſerved that this earthy ſalt does not melt in the focus of M. de Trudaine's lens, the fuſion effected by M. d'Arcet was owing, doubtleſs, to the clay of the crucible.

Calcareous

Calcareous carbonate ſuffers no alteration from pure air: but the rays of the ſun acting upon it in a humid atmoſphere, deſtroy its tranſparency and the coheſion of its laminæ. Its ſurface aſſumes the colours of the rainbow, becomes dark, and gradually deliquiates.

It does not appear to be ſoluble in water. Chalk, though not more ſoluble in this fluid than calcareous carbonate, is however maintained in ſolution by ſtreams of water running over beds of cretaceous matter. In ſome inſtances water contains a conſiderable quantity of it. Of this kind are the waters of Arcueil near Paris: which contain ſo much chalk, that in a few months they depoſite incruſtations on bodies immerſed in the canals through which they run. The bath waters of St Philip in Italy are ſo ſtrongly impregnated with this ſubſtance, as to depoſite layers of it half an inch thick in the ſpace of a few days. Tablets and figures of this matter are obtained from theſe waters, by immerſing into them hollow moulds, in which the cretaceous matter is accumulated

Calcareous carbonate contributes to the vitrification of ſeveral earthy and ſtony ſubſtances: when mixed with ſiliceous earth in the proportion of two-thirds or three-fourths, it cauſes it to melt.

This ſalt, when mixed by nature with an argillaceous earth, compoſes a mixed earthy matter, to which naturaliſts and farmers give the name of *marl*. That ſubſtance of which there are very many varieties, differing from each other in colour, denſity, &c. melts, when expoſed to a ſtrong fire, into a greeniſh yellow

glaſs.

glaſs. It is uſed with great ſucceſs in agriculture to ſoften and fertilize ſoils.

Barytes and magneſia have no action on calcareous carbonate in the humid way: the carbonic acid has a ſtronger affinity with lime than with either of thoſe two ſubſtances. But when calcareous carbonate is expoſed to fire with theſe alkaline earths, it enters into a vitreous combination with them. M. Achard has made many experiments on all of theſe vitreous mixtures; of which a particular account is given in the *Journal de Phyſique.*

The fixed alkalis and ammoniac produce no alteration on calcareous carbonate, becauſe the carbonic acid has a greater affinity with lime than with any of thoſe ſalts.

The ſulphuric, the nitric, the muriatic, and the fluoric acids, decompoſe this ſalt by ſeizing its baſe and diſengaging the carbonic acid. When the ſulphuric acid is poured on calcareous carbonate, it excites ebullition, by diſengaging the carbonic acid in a gaſeous form. Naturaliſts have very happily aſſumed this property as a general characteriſtic of calcareous ſubſtances. With acids, an accurate analyſis of calcareous carbonate may be effected. In order to this, let the ſalt be reduced to powder, and a quantity of ſulphuric acid be poured upon it. The violent effervеſcence which ariſes at the inſtant when the two ſubſtances are mixed, ſhows the carbonic acid to be then ſeparated: and it may be obtained, and its quantity meaſured in a receiver, with the help of a ſyphon and bell-glaſſes filled with mercury. The effervеſcence is attended with cold, occaſioned by the volatilization of the acid.

acid. When it ceaſes, if the new combination be examined, it is found to be calcareous ſulphate, formed by the union of the ſulphuric acid with the lime, which was the baſe of the former ſalt. Late experiments have ſhown, that ſeveral of theſe ſpars contain a little magneſia, and afford ſulphate of magneſia, when diſſolved by the vitriolic acid. The nitric acid commonly made uſe of by naturaliſts, in aſſaying calcareous ſtones, produces the ſame efferveſcence with calcareous carbonate as the ſulphuric acid: it diſengages the carbonic acid, and forms calcareous nitrate with its baſe.

The muriatic acid likewiſe ſeparates the acid from calcareous carbonate with a violent efferveſcence, and produces muriate of lime by combining with its baſe.

The fluoric acid likewiſe decompoſes this ſalt, forming calcareous fluate with its baſe.

The boracic acid, when cold, does not decompoſe calcareous carbonate; but cauſes it to efferveſce when heated by being mixed with powdered chalk, and diluted with a ſufficient quantity of water.

The carbonic acid renders carbonate of lime, or calcareous matters in general, ſoluble. We have already ſeen in the hiſtory of that acid, that it cauſes lime water to give a precipitate of chalk, but diſſolves it again on the addition of more of the acid than what is neceſſary to effect the precipitation. Water impregnated with the carbonic acid, when left ſtanding above a quantity of calcareous carbonate in powder, becomes at length impregnated with a certain quantity of this earthy neutral ſalt. Various waters acquire alſo chalk by means of the acid; but none of theſe ſolutions are laſting.

When

When expoſed to the air, they aſſume gradually a turbid appearance; and in proportion as the carbonic acid eſcapes, the chalk is precipitated. Heat cauſes this effect to take place much more rapidly. And for this reaſon, waters which are hard and crude by being impregnated with chalk, may be corrected by boiling.

As it is almoſt always owing to the carbonic acid that water maintains chalk in ſolution, we may naturally infer that this earthy ſalt muſt be precipitated when the acid evaporates. Such is the origin of the incruſtations and accumulations of calcareous matter which are formed in fountains and on the ſides of channels through which water of this character flows; as may be obſerved of the water of Arcueil and the bath-waters of St Philip in Italy. Before natural hiſtory was illuſtrated by chemiſtry, ſprings exhibiting ſuch incruſtations were called *petrifying fountains*, and ſuperſtition held them to be miraculous.

Calcareous carbonate does not act in any manner on neutral ſalts with a baſe of fixed alkali. It decompoſes ammoniacal ſalts. By this decompoſition we obtain on the one hand a calcareous ſalt, formed of the acid of the ammoniacal ſalt with lime; on the other, ammoniacal carbonate produced by the combination of the carbonic acid with ammoniac. This operation is performed by diſtilling in a ſtone retort a mixture of a pound of ſal ammoniac with two pounds of chalk, or rather calcareous ſpar in powder. Both of theſe ſubſtances muſt be very dry. A long necked balloon muſt be fitted to the retort, or, what is ſtill better, a ſtone or glaſs cucurbite. Fire is to be gradually applied till the

bottom of the retort be made red-hot; and the receiver muſt be cooled with wet clothes, or with cold water kept running around it during the whole of the operation. White vapours ariſe, and are condenſed on the ſides of the receiver into very white pure cryſtals. Theſe are ammoniacal carbonate. This is the proceſs by which it is prepared in London, from which it was formerly retailed over all Europe under the name of *Engliſh ſal volatile*. This ſalt is now prepared in other countries as well as in England. The reſidue after this operation is calcareous muriate with an exceſs of lime, generally in fuſion, if the fire have been ſtrong towards the end of the operation.

Spar and calcareous matters in general are applied to many purpoſes, as we have already obſerved when treating of their natural hiſtory; but one of the moſt important is the preparation by which they are reduced to lime. The lime-burner decompoſes calcareous matters, driving off their acid by the action of fire. Stones containing ſhells, marbles, and moſt calcareous ſpars, are the ſubſtances which afford the beſt lime; but the ſtone which is generally uſed for the purpoſe, more eſpecially in the neighbourhood of Paris, is a kind of hard calcareous ſtone, known by the name of *lime-ſtone*. Theſe ſtones are built into a kind of oven or turret, forming an arch. A fire of wood is kindled under the arch, and kept up till a pure lively flame, without ſmoke, ariſe about ten feet above the oven, and the ſtones become very white. Mineral coals and peats begin to be uſed in the neighbourhood of Paris for burning lime.

Good

Good lime is hard and ſonorous, becomes very hot on being brought into contact with water, and when ſlaked, exhales a thick ſmoke. When not ſufficiently calcined, it is not ſo ſonorous, nor does it become ſo ſoon hot with water, or to ſo high a degree. If too much burnt, it is half vitrified; it then yields, when ſtruck, too clear a ſound, and does not unite readily with water. The lime-burners then call it *burnt lime*. We need not here ſpeak of the purpoſes to which lime is applied, as we have taken notice of them in treating of the pure ſubſtance.

We may here add, that the calcareous carbonate, which is found mixed in very ſmall fragments with calcareous ſulphate, and exiſts in mountains, in extenſive ſtrata, moſt commonly regular, and ſeparated by clay and marl, as in the vicinity of Paris, is the beſt plaſter ſtone for building. Though we have already adverted to this in the article of calcareous ſulphate, it may be not improper to return to it in this place, and to enter into ſuch a detail of particulars as may ſupply what is wanting on this head in all works on natural hiſtory and chemiſtry.

We muſt firſt recollect that pure calcareous ſulphate gives only fine plaſter by calcination; which makes but an incoherent paſte with water, and is caſt into ſtatues. It is univerſally known, that this paſte when dry is not tenacious, and is ſo brittle that the ſmalleſt degree of reſiſting force is ſufficient to break it. The reaſon is, that when this ſaline matter regains the water which is loſt by calcination, it forms an equal homogeneous maſs. This is by no means the caſe with plaſter, fit for the purpoſes of building. The ſtone

which affords it at Montmartre and other places, is a kind of breccia, conſiſting of very ſmall granulated cryſtals of ſulphate of lime, with very thin plates of calcareous carbonate. The preſence of the latter ſubſtance may be aſcertained by dropping a little of the nitric acid on the ſtone; it produces a lively efferveſcence by diſengaging the carbonic acid. If a given weight of Montmartre plaſter ſtone be diſſolved in a ſufficient quantity of aquafortis, the calcareous carbonate is entirely decompoſed, its lime unites with the nitric acid, and what remains is calcareous ſulphate, a ſubſtance inſoluble in this acid. This experiment ſhows, that the proportion of calcareous carbonate varies in different plaſter ſtones; and that in the beſt it conſtitutes rather more than a third part.

This fact concerning the mixed nature of plaſter ſtones being fully eſtabliſhed, it is eaſy to comprehend the nature of the phænomena which building plaſter exhibits when burnt, ſlaked, and hardening. When this earthy ſalt is burnt, the calcareous ſulphate which it contains loſes the water of its cryſtals, and becomes friable; while the calcareous carbonate, at the ſame time loſing its acid, becomes a calx. On this account, plaſter which has been properly burnt, is acrid and alkaline, communicates a green colour to ſyrup of violets, acquires heat when brought into contact with the acids, without efferveſcing, and gradually loſes its ſtrength when expoſed to the air, in proportion as the quicklime which it contains is ſlaked, by attracting water and carbonic acid from the atmoſphere. When wrought

into

into mortar, it gives out heat, in proportion as it abſorbs water. As to its ſolidity, (which it is well known to aſſume very readily), a characteriſtic property in which it is directly oppoſite to pure lime, the quicklime contained in the maſs ſoon abſorbs as much water as is requiſite to ſlake it, and the calcareous ſulphate intermixed among its particles, likewiſe attracting a certain portion, is ſuddenly cryſtallized, and acts the part of ſand or cement, by uniting and conſolidating the lime.

Laſtly, This theory explains why plaſter retains its characteriſtic properties, when kept dry and expoſed to heat; but when expoſed to moiſture, gradually loſes them and waſtes away. Theſe phænomena are owing to its being compoſed of two ſaline principles, both ſoluble in water.

CHAP. VIII.

Genus IV. *Neutral Salts, with a baſe of Magneſia, or Magneſian Salts.*

WE have already ſeen in the hiſtory of acids, that magneſia readily combines with thoſe ſalts, forming by this combination a peculiar genus of neutral ſalts. Theſe neutral ſalts are as yet but imperfectly known, few chemiſts have made them the ſubject of their inquiries. The celebrated Dr Black* firſt diſtinguiſhed them as a peculiar genus of ſalts; they were before confounded with other neutral ſalts, having an earthy baſe.

Magneſian ſalts poſſeſs generic characteriſtics. Almoſt all of them are bitter and ſaline: and they may be obtained, though not without difficulty, in regular cryſtals. Moſt of them diſſolve very readily in water, and ſome even attract the moiſture of the atmoſphere. They are

* See *Dr Black's* paper of experiments on *Magneſia*, printed and publiſhed, together with *Cullen* on the evaporation of fluids, in one ſmall pamphlet. H.

are eaſier decompoſed than ammoniacal or calcareous ſalts; barytes, lime, the fixed alkalis, and even ammoniac in part, rob them of their acids. Ammoniac enters into union with both magneſia and an acid at the ſame time; and thus forms ammoniaco-magneſian ſalts, conſiſting of three principles.

In this chapter we mean to examine ſix of theſe ſalts; namely, magneſian ſulphate or Epſom ſalt, magneſian nitrate, magneſian muriate, magneſian borate, magneſian fluate, and magneſian carbonate.

Species I. *Sulphate of Magneſia, or Epſom Salt.*

The neutral ſalt formed by the combination of the ſulphuric acid with magneſia, has received the name of *Epſom ſalt*, from Epſom wells in England, where it was formerly obtained in great abundance. It is likewiſe found in the waters of Egra, Sedlitz, and Seydſchutz†. Its proper name is *ſulphate of magneſia, or magneſian ſulphate.*

This ſalt has a very bitter taſte, from which it has been called *bitter cathartic ſalt.* In commerce it appears in ſmall needles, terminating in very ſharp pointed pyramids; in which ſtate it is pretty much like ſulphate of ſoda, or *Glauber ſalt;* but when regularly cryſtallized, it is of a more bitter taſte, does not effloreſce in the air, and gives cryſtals of a very different form. When ſuffered to cryſtallize ſpontaneouſly, its

† *M. Chaptal* relates, that the ſulphate of magneſia, common in *France*, is obtained from the ſalt ſprings of *Lorraine*, or from the ſalt works near *Narbonne.* H.

cryſtals are fine quadrangular priſms, terminating in pyramids, which are alſo quadrangular. The ſides of thoſe priſms and pyramids are ſmooth and plain, and the cryſtals are generally ſhorter and thicker than thoſe of ſulphate of ſoda. All its other properties, as we ſhall hereafter ſee, concur to diſtinguiſh it from that perfect neutral ſalt.

Sulphate of magneſia, like ſulphate of ſoda and borax, retains in its cryſtals enough of water to make it ſuſceptible of aqueous fuſion. The moſt moderate heat is ſufficient to melt it: when cooled after this fuſion, it becomes a ſhapeleſs maſs. If it remain expoſed to fire after this aqueous liquefaction, it dries into a white friable maſs, which is the ſalt unaltered, only, without the water which entered into its cryſtals. A very intenſe heat is requiſite to bring magneſian ſulphate to an actual igneous fuſion. This ſalt in cryſtals contains a quantity of water nearly equal to half its weight.

Macquer and ſeveral other chemiſts ſay, that when expoſed to the air, it becomes ſomewhat moiſt, and that it may be diſtinguiſhed by this property from ſulphate of ſoda which efflorefces. Bergman again informs us, that when magneſian ſulphate is expoſed to the atmoſphere in a dry ſtate, it immediately loſes its tranſparency, and is at length reduced to a white powder: he adds, that the magneſian ſulphate in ſmall needles, which is commonly ſold in the ſhops, owes its moiſt deliquefcent appearance to the magneſian muriate which it contains. M. Butini, a citizen of Geneva, to whom we are indebted for a number of valuable experiments on magneſia, mentions his having found ſulphate of ſoda,

ſoda, or Glauber ſalt, in Engliſh Epſom ſalt: and to this the efflorescence may be attributed. But pure ſulphate of magneſia, though it loſe its tranſparency in the air, is far from being ſo liable to efflorescence as ſulphate of ſoda, which at the end of a certain time is entirely reduced to a powder.

Sulphate of magneſia diſſolves in water ſo readily, that rather leſs than two parts of cold water are ſufficient to maintain one part of this ſalt in ſolution; and warm water diſſolves a quantity of it equal nearly to twice its own weight*. It cryſtallizes by cooling; but in order to obtain it in very regular cryſtals, we leave the ſolution to cryſtallize when cold by ſpontaneous evaporation. This ſalt ſuffers no alteration from either ſiliceous or aluminous earth.

Barytes decompoſes it, having a greater affinity than magneſia with the ſulphuric acid.

Lime, for the ſame reaſon, decompoſes it. If a little ſulphate of magneſia be poured into lime-water, or a certain quantity of lime-water be poured into a ſolution of this ſalt, a precipitate is produced, conſiſting of magneſia and calcareous ſulphate. Recourſe may be had at any time to the precipitation, as a ſure criterion to enable us to diſtinguiſh magneſian ſulphate from ſulphate of ſoda.

The pure fixed alkalis likewiſe decompoſe ſulphate of magneſia. Cauſtic ammoniac has the ſame influence on this ſalt; and as it does not decompoſe calcareous ſulphate, we learn from theſe facts, that it has a ſtronger affinity with the ſulphuric acid than magneſia, and a weaker

* M. *Chaptal* ſays, that at the temperature of 60° Fahrenheit water diſſolves a quantity of magneſia equal to itſelf in weight. H.

weaker than lime. Thus we gain a certain criterion by which we may diſtinguiſh when magneſian ſulphate exiſts in water. In this manner, by the uſe of cauſtic ammoniac, pure magneſia, of which we gave the hiſtory in entering on the conſideration of ſaline matters, may be obtained. Yet Bergman has obſerved, that ammoniac does not effect an entire precipitation of the magneſia of Epſom ſalt; part ſtill remains unaltered. The liquor in which the two ſubſtances are mixed, maintains both ammoniacal and magneſian ſulphate in ſolution at the ſame time. Chemiſts have aſſerted that theſe two ſalts join to form a third, conſiſting of an acid and the two baſes. But to prevent miſtakes, we muſt obſerve, that though theſe ſalts be found together in the ſame water, yet the one conſiſts of ammoniac in combination with the ſulphuric acid, while the other is a combination of magneſia with the ſame acid. Each poſſeſſes a diſtinct portion of the acid; both the baſes are by no means in union with the ſame portion of the acid; yet thoſe two ſulphates have a pretty ſtrong mutual affinity; they cryſtallize together, and thus produce what may be called *a triple ſalt*, or *ammoniaco-magneſian ſulphate*.

We know not well in what manner magneſian ſulphate affects thoſe neutral ſalts which have for their baſe a fixed alkali or ammoniac: probably it would decompoſe the nitric and the muriatic ſalts with theſe baſes by a double affinity.

M. Quatremere Dijonval aſſerts, in a letter to M. de Morveau, (*Journal de Phyſique*, May 1780, vol. xvii. page 391.), that when a ſolution of ſulphate of magneſia is brought into contact with a ſolution of ammoniacal

niacal ſulphate, the former ſalt is entirely precipitated without being decompoſed: it falls to the bottom of the glaſs in large cryſtals, the taſte of which indicates their nature. He aſcribes this effect to the property which ammoniacal ſulphate poſſeſſes, of attracting water from ſulphate of magneſia, which he believes to cryſtallize very readily. But this is a miſtake; for the ſalt cryſtallized on this occaſion is a real triple ſalt, or ammoniaco-magneſian ſulphate, as I know from unequivocal experiments.

The carbonic ſalts and magneſian ſulphate mutually decompoſe each other. When a ſolution of carbonate of poraſh or ſoda is poured into a ſolution of magneſian ſulphate, a double decompoſition and a double combination take place. The ſulphuric acid of Epſom ſalt combines with the fixed alkali, and the carbonic acid ſeparated from the alkali unites with the magneſia, to form the neutral ſalt known by the name of *mild or efflorescent magneſia*, and which we call *carbonate of magneſia*. The mild magneſia, uſed in medicine as an excellent purgative, is prepared in this manner. I ſhall give a minute deſcription of the proceſs at the end of this chapter.

According to M. Dijonval, when a ſolution of ſulphate of lime is mixed with a ſolution of ſulphate of magneſia, the latter ſalt is precipitated: but the quantity of calcareous ſulphate that can be maintained in ſolution is ſo ſmall, that this phænomenon is ſcarcely diſcernible. Calcareous nitrate and calcareous muriate likewiſe decompoſe ſulphate of magneſia, and are decompoſed by it in their turn: but we cannot think this fact warrants the concluſion which M. Dijonval deduces from

from it, namely, that the nitric and the muriatic acids have a greater affinity than the ſulphuric acid with magneſia; for it is evident that double elective attraction acts in theſe inſtances.

Bergman ſays, that a quintal of ſulphate of magneſia in cryſtals contains nineteen parts of pure magneſia, thirty-three of ſulphuric acid, and forty-eight of water. *

Sulphate of magneſia, or Epſom ſalt, is of conſiderable uſe in medicine. It is a good purgative, and acts at the ſame time as a diſcuſſive. It is even preferred to other purgative ſalts, on account of its extreme ſolubility. It is either given by itſelf, diſſolved in water, in doſes of from one to two ounces; or a dram or two of it adminiſtered along with ſome other medicine. Moſt waters that are naturally purgative derive their mineral qualities from it, more eſpecially thoſe of Egra, Sedlitz, and Seydſeutz: but they likewiſe contain muriate of magneſia.

Species II. *Magneſian Nitrate.*

MAGNESIAN nitrate, which chemiſts have hitherto called *nitre of magneſia*, or *nitrated magneſia*, has been examined

* *M. Chaptal* relates, that the magneſian ſulphate prepared in the *French* ſalt works is ſold at from 30 to 40 livres a quintal; and contains, in the pound weight, $\frac{3}{8}$ lb of ſulphate of ſoda, $\frac{3}{8}$ of muriate of magneſia, $\frac{1}{8}$ muriate of ſoda, $\frac{1}{8}$ pure ſulphate of magneſia, and $\frac{4}{8}$ of ſalts with a baſe of lime.

He likewiſe informs us, that magneſian ſulphate exiſts in all the waters in the neighbourhood of *Montpellier*; that it is ſometimes found efflorescent upon Schiſti; that he had found it on a mountain in *Rouergue*, in a quantity ſufficient to deſerve collection; and that birds of paſſage devour it greedily. H.

examined by Bergman. That illuſtrious chemiſt ſays, an artificial ſolution of this ſalt gives, after a proper evaporation, priſmatic, quadrangular, and ſpathoſe cryſtals, without pyramids.

This ſalt has an acrid and very bitter taſte; heat decompoſes it; and it imbibes moiſture in the air. It diſſolves very readily in water; a ſlow evaporation is requiſite to make it cryſtallize; and we are even ſo imperfectly acquainted with the laws of its cryſtallization, that we cannot make it aſſume a regular form at pleaſure, like many of the other ſalts. Barytes, lime, and the alkalis, decompoſe it.

As magneſian nitrate is found diſſolved in mother-water of nitre, M. de Morveau has propoſed precipitation by lime-water, as a method of obtaining the magneſia in the great way. This proceſs, being ſo cheap and eaſy, might be employed with great advantage; but as the ſame chemiſt has obſerved that freſh lime water precipitates pure calcareous nitrate when magneſian nitrate is diſſolved in too ſcanty a proportion of this water; the magneſia obtained by this proceſs would not poſſeſs the degree of purity requiſite to render it an uſeful medicine, unleſs the mother-water were diluted in a large quantity of common water.

The ſulphuric and the fluoric acids diſengage the acid from nitrate of magneſia. The boracic acid likewiſe ſeparates it with the help of heat, in conſequence of its fixity. Theſe properties of this ſalt have been pointed out by Bergman.

M. Quatremere Dijonval, who has examined many of the combinations of magneſia, has found magneſian nitrate to poſſeſs ſome properties very different from

thoſe

thoſe aſcribed to it by the chemiſt of Upſal. He tells us, that he obtained cryſtals of magneſian nitrate, not liable to deliquium; and adds, that magneſian ſalts are not leſs diſpoſed to cryſtallize and efflorefce than calcareous ſalts to attract moiſture. *

Nitrate of magneſia appears to be capable of decompoſing ſulphate of potaſh, ſoda, or ammoniac, by double affinity. But theſe decompoſitions are not ſo obſervable when ſolutions of the ſalts are mixed together, as the decompoſitions effected by calcareous nitrate; becauſe the nitrates of potaſh, ſoda, or ammoniac, as well as the ſulphate of magneſia, conſequently produced, are all very ſoluble in water; whereas the ſulphate of lime produced by the decompoſition of ſulphate of potaſh, ſoda, or ammoniac, by calcareous nitrate, gives a very copious precipitate. By evaporating the liquors, however, we can make ourſelves certain of the effects produced by magneſian nitrate on the above mentioned ſalts. Nitrates are found to be formed by the union of the alkalis with the nitric acid; and ſulphate of magneſia by the combination of ſulphuric acid from the decompoſed ſalts with the baſe of magneſian nitrate.

M. Dijonval mentions a fact which well deſerves the attention of chemiſts. It is the precipitation of magneſian nitrate by calcareous nitrate. When pure tranſparent ſolutions of theſe two ſalts, ſays he, are mixed together, the magneſian nitrate is immediately depoſited on the bottom of the veſſel in a cryſtalline form, and

* M. Chaptal relates, that he himſelf had accidentally found in mother-water of nitre, concentrated to the 45° of the aræometer, a non-deliqueſcent cryſtal of magneſian nitrate; prismatic with four ſides, very much flattened, very thick, and very ſhort. H.

and not at all altered; but the calcareous nitrate remains diſſolved in the liquor. It is very ſingular, that of two ſalts which remain diſſolved, if they be kept ſeparate, one is inſtantly precipitated in cryſtals when they are brought into contact with each other. M. Dijonval thinks, as we have mentioned above, that this depends on the ſtrong tendency of calcareous nitrate to combine with water. This ſalt being, in his opinion, capable of abſorbing a greater quantity of water than what is neceſſary to maintain it in ſolution: when mixed with a ſolution of magneſian nitrate, which has an equal tendency to cryſtallization; it robs this laſt ſalt even of the water of its cryſtals; and the magneſian nitrate then acquiring greater ſpecific gravity, is precipitated in a cryſtalline form. There are, however, ſeveral difficulties not ſolved by this explanation. How can any ſalt, however great its tendency to ſolution, abſorb the water belonging to the cryſtals of another ſalt, when it is itſelf already combined with a quantity of that liquid ſufficient to maintain it in ſolution? If it be anſwered, that it is not ſaturated with water, there muſt then be a certain point of ſaturation, at which calcareous nitrate would ceaſe to precipitate magneſian nitrate; and this ſhould ſurely have been ſhown. But though this were granted, how could calcareous nitrate deprive magneſian nitrate of the water of its cryſtals, and yet ſuffer it to be precipitated in a cryſtalline form? Laſtly, How is it poſſible that magneſian nitrate, after loſing its water of cryſtallization, can be inſtantaneouſly precipitated in cryſtals? We are thus induced to think that ſome particulars muſt have eſcaped M. Dijonval's obſervation;

and

and that the true cauſe of this phenomenon is not likely to be diſcovered till ſuch time as the experiment ſhall have been again and again repeated with various quantities of water, and of the ſalts, as well as in various temperatures, &c.

Magneſian nitrate is not applied to any uſe either in the arts or in medicine. Its ſtrong taſte, its tendency to deliquiate, and indeed all its properties, lead us to think, that it would act powerfully on the animal œconomy; and it is much to be wiſhed that it were tried as a diſſolvent and inciſive in all caſes in which medicines of this nature are requiſite.

Species III. *Magneſian Muriate.*

This ſalt, which is a ſaturated combination of the muriatic acid with magneſia, exiſts in all ſalt waters, and in all waters containing magneſian ſulphate in a ſtate of ſolution; ſuch as thoſe of Epſom, Egra, Sedlitz, and Seydſchutz, as well as many others. It is much more common than it was once thought to be.

Magneſian muriate has a very bitter and hot taſte. Bergman ſays, that the only way of obtaining it in cryſtals is by expoſing a ſolution of it, highly concentrated by evaporation, to a ſudden and extreme cold. It is then obtained in the form of ſmall needles, having a ſtrong tendency to deliquiate. The ſolution is commonly a tranſparent jelly: But M. Dijonval ſays, that he obtained this ſalt in a regular permanent form; and that it has a tendency rather to efflorеſce than to deliquiate.

Magneſian

Magneſian muriate is decompoſed and deprived of its acid by the action of fire. It is very difficult to drive off the laſt remains of the acid: after this operation the magneſia remains cauſtic.

When this ſalt is expoſed to the air, it appears to attract moiſture eagerly, and is ſoon diſſolved into a liquid. Bergman and ſeveral other chemiſts have taken notice of its poſſeſſing this property. M. Dijonval, however, ſays, that magneſian muriate, like magneſian nitrate, rather efflores̈ces than attracts moiſture. But this aſſertion needs farther confirmation by experiment.

Magneſian muriate diſſolves very readily in water; it even appears, that a portion of the fluid equal to itſelf in weight is ſufficient to maintain any quantity of this ſalt in ſolution. It is very difficult to obtain this ſalt in regular cryſtals. Evaporation by heat ſucceeds very ill; for it concentrates the liquor too much; which, when cooled, aſſumes almoſt always the conſiſtency of a jelly. Spontaneous evaporation in a ſummer temperature is more likely to cryſtallize this ſalt: but even this method is attended with great difficulties.

Muriate of magneſia, heated in a retort with ſilice and lumine gives out its acid; but as the action of fire alone is ſufficient to produce this effect, it is not to be attributed to the earths.

Barytes and lime decompoſe this ſalt by precipitating the magneſia. As the mother-waters of muriate of ſoda in ſalt ſprings contain muriate of magneſia mixed with calcareous muriate, the magneſia which theſe ſalts

contain may be precipitated in the great way, and at a ſmall expence, by means of lime-water.

The fixed alkalis and cauſtic ammoniac have a greater affinity than magneſia with the muriatic acid, and cauſe the baſe of magneſian muriate to precipitate. The muriate of potaſh, ſoda, or ammoniac, according as the one or the other of theſe ſalts has been employed, remains diſſolved in the liquor. Ammoniac does not entirely decompoſe this ſalt, but forms a triple cryſtallizable muriatic ſalt with the remaining portion of it.

The ſulphuric and the nitric acids decompoſe this ſalt, ſeparating the muriatic acid with effervescence. In order to effect theſe decompoſitions, a mixture, conſiſting of one part of either of theſe acids and two parts of muriate of magneſia, is to be diſtilled in a glaſs retort. The acid belonging to the magneſian muriate is volatilized, while the other acids being ſtronger, combine with the magneſia to form magneſian ſulphate or nitrate. The boracic acid likewiſe diſengages the muriatic acid with the help of heat.

Magneſian muriate decompoſes ſulphuric and nitric ſalts, with a baſe of fixed alkali or ammoniac, by the way of double affinity. But in order to render theſe decompoſitions apparent, the ſolutions of the ſalts muſt firſt be poured upon a ſolution of magneſian muriate, and then evaporated, or mixed with ſpirit of wine; for the new ſaline matters formed by the decompoſition remain diſſolved in the water after it is effected.

When muriate of magneſia is brought into contact with muriate of potaſh, and both are in a ſtate of ſolution, the former ſalt is precipitated in cryſtals, according

cording to M. Dijonval, in conſequence of its having a much greater tendency to cryſtallization than the other; which takes poſſeſſion of the water by which it was maintained in ſolution. But it is difficult to conceive how any ſalt which has ſo ſmall a tendency as muriate of potaſh to diſſolve or deliquiate, can rob another ſalt, ſo ſoluble as magneſian muriate, of the water by which it was diſſolved. The ſame chemiſt informs us, that when a ſolution of magneſian muriate is mixed with a ſolution of calcareous muriate, the former ſalt is precipitated in cryſtals. But farther experiments are neceſſary to give theſe aſſertions ſuch authority as may intitle them to rank among the elements of the chemical ſcience. Very likely, the cryſtals precipitated are not pure, but to be referred to the claſs of triple ſalts.

Magneſian muriate is not applied to any uſe: but, in my opinion, it might be very happily uſed in medicine as a purgative and diſſolvent. Phyſicians always adminiſter ſmall quantities of it when they preſcribe Epſom or Sedlitz waters, or grey marine ſalt; for theſe ſubſtances ſtill contain more or leſs of it.

Species IV. *Magneſian Borate.*

This name is given to the combination of the boracic acid with magneſia. This ſalt is ſcarce known. Bergman has obſerved, that when a portion of magneſia is caſt into a ſolution of the boracic acid, it is ſlowly diſſolved. This liquor, when evaporated, affords granulated cryſtals of an irregular form.

Fire melts, but does not decompoſe this ſalt. The acids decompoſe it by attracting the magneſia, and ſeparating the boracic acid. Spirit of wine likewiſe carries off the acid, leaving the magneſia by itſelf. It appears therefore that magneſia does not adhere very cloſely to the acid of borax.

We muſt therefore confeſs ourſelves to be very little acquainted with the properties of this ſalt, as chemiſts have made but very few experiments upon it.

Species V. *Magneſian Fluate.*

MAGNESIA in combination with the fluoric acid receives the name of *magneſian fluate*, and is not better known than magneſian borate. Bergman is the only chemiſt who has ſaid any thing of it. According to him, the fluoric acid diſſolves magneſia very quickly; and when the acid is nearly ſaturated, a great part of the new-formed ſalt is precipitated.

The ſolution affords, by ſpontaneous evaporation, a kind of tranſparent froth which hangs at the ſides of the veſſel, conſiſting partly of long and very fine cryſtalline threads. There are at the ſame time obtained, in the bottom of the veſſel, ſpathoſe cryſtals in hexagonal priſms, terminating in a ſhort pyramid conſiſting of three rhombs. This ſalt is liable to no alteration from even the extreme violence of fire. No acid has ſtrength to decompoſe it in the humid way. This neutral fluoric ſalt, to which Bergman has attributed ſuch extraordinary properties, is well worthy of a more particular examination

Species

Species VI. *Magneſian Carbonate.*

This ſalt, to which Dr Black, the firſt diſcoverer of it, has given the name of *mild or effervescing magneſia*, is formed, as the name we have given it indicates, by a ſaturated combination of magneſia with the carbonic acid. It is commonly prepared by precipitating a ſolution of magneſian ſulphate with carbonate of potaſh or ſoda, in a way which we ſhall deſcribe at the end of this article.

Magneſian carbonate has moſt generally an earthy appearance: it is in the form of a very white powder. Yet Bergman and M. Buſſini of Geneva obtained it in cryſtals by a proceſs which we are hereafter to deſcribe. Like all other carbonic ſalts, it may contain either a greater or a leſs proportion of the acid; and its properties vary according to the proportion in which the acid exiſts in it. Its taſte is crude and earthy. But it affects the inteſtines in a more ſenſible manner; for it is purgative.

This ſalt, when expoſed to fire in a crucible, loſes both the water and the acid which it contains. M. Tingry, apothecary at Geneva, has obſerved, that when effervescing magneſia is calcined in the great way, it bubbles, and exhibits on its ſurface the motion of a fluid. This phænomenon is owing to the diſengagement of the acid gas. There ariſes out of the crucible a thin vapour, which depoſites on contiguous bodies a white duſt that is readily known to be magneſia carried off by the current of the carbonic acid. If a warm body be immerſed in the crucible, the ſalt ad-

heres to it; a cold body attracts ſtill more. Towards the end of the operation, the magneſia diſplays a bluiſh phoſphoric light, which in the dark is very diſcernible.

By calcining carbonate of magneſia in cloſe veſſels, with a pneumato-chemical apparatus, we obtain the water and the acid of the ſalt. M. Butini, who performed this operation in a very exact manner, informs us, from a calculation founded on the products which he obtained, that thirty-two grains of common magneſia (what he calls *common magneſia* is a kind of magneſian carbonate prepared for pharmaceutical purpoſes, and not completely ſaturated with the acid) conſiſt of about thirteen grains of pure earth, twelve of the acid, and ſeven of water. Bergman reckons a quintal of this ſalt to contain twenty-five or thirty parts of the acid, according to its particular ſtate, thirty of water, and forty-five of pure magneſia. If expoſed to a more intenſe heat, after loſing its acid, it is agglutinated and becomes hard, like pure or cauſtic magneſia.

Magneſian carbonate ſuffers no very remarkable alteration from air; yet, when expoſed to a damp atmoſphere, it aſſumes the form of little clods, and appears to deliquiate in ſome degree.

Water diſſolves but a very ſmall proportion of this ſalt; and its ſolubility in water varies, according as it contains more or leſs of the acid. When a quantity of the ſalt is mixed with a ſmall portion of water, it compoſes a kind of paſte; which, however, is not very tenacious, and dries up without acquiring conſiſtency, or ſhrinking into a ſmaller bulk. If diluted in a very large proportion of water, magneſian carbonate diſſolves gradually,

gradually, at the rate of a quarter of a grain of the ſalt to an ounce of the fluid; as appears when the liquor is evaporated. But there are ways of making this ſalt diſſolve in a much larger proportion; which we ſhall immediately mention.

Pure earths do not decompoſe carbonate of magneſia. Lime robs it of its acid. Lime water poured into a ſolution of this ſalt, occaſions an obſervable precipitation, however ſmall the quantity of the neutral ſalt diſſolved in the water. The precipitate conſiſts of carbonate of lime, and a little cauſtic magneſia, which is known to be almoſt inſoluble.

The fixed alkalis and cauſtic ammoniac likewiſe decompoſe this ſalt; for they, as well as lime, have a greater affinity than magneſia with the carbonic acid. The reſults of theſe mixtures are carbonate of potaſh, ſoda, or ammoniac, and pure cauſtic magneſia,—which is precipitated.

The ſulphuric, the nitric, and the muriatic acids, decompoſe magneſian carbonate in a directly contrary way. They unite with the magneſia, with which they have a ſtronger affinity than the carbonic acid; and they occaſion an effervescence by diſengaging that acid under a gazeous form. The carbonic acid which eſcapes on the occaſion is diſtinguiſhed by its uſual characteriſtics. M. Butini obſerved, in his experiments, that it was rather the fire than the acids which diſengaged the carbonic acid; and that each of theſe ſalts ſeparated a different quantity. Thus, for inſtance, he found the muriatic acid to diſengage more than the nitric, and the nitric more than the carbonic.

From theſe facts he concluded, that neutral ſalts, conſiſting of magneſia in combination with an acid, namely ſulphate and nitrate of magneſia, ſtill retain a portion of the carbonic acid.

The carbonic acid poſſeſſes the property of rendering carbonate of magneſia much more ſoluble than the pure ſalino-terrene matter. M. Butini's late experiments have been chiefly directed to determine the phænomena of this ſolution. He has diſcovered, that when any quantity of common magneſia, not ſaturated with the carbonic acid, is thrown into water in a gazeous ſtate, or impregnated with the acid, the magneſia immediately abſorbs as much acid from the water as is requiſite to ſaturate it, and even does not diſſolve till it be ſuper-ſaturated. This ſolution communicates a green tincture to ſyrup of violets. When expoſed to cold, it loſes its exceſs of acid; but the magneſia is not ſeparated from the water, even though it be frozen into ice. When a ſolution of magneſia, ſuper-ſaturated with carbonic acid, is expoſed to heat, it loſes its tranſparency, but regains it when ſuffered to cool. This ſingular phænomenon offers to our obſervation, as M. Butini has very well obſerved, a new kind of ſalts, to which it is peculiar, to diſſolve in a larger proportion in cold than in hot water. The more magneſia any gaſeous ſolution contains, the ſooner does it loſe its tranſparency by heat. In order to have a proper opportunity of obſerving how this ſalt, from muddy, becomes tranſparent as it cools, the above mentioned chemiſt directs us to take a ſolution, containing two grains of magneſia to an ounce of water, and to heat it 168° 52' of Fahrenheit's thermometer.

ter. Heat gives it a milky conſiſtency; but all the magneſia now precipitated is again diſſolved by cold.

Bergman had before obſerved, that when a ſolution of magneſia impregnated with carbonic acid was ſlowly evaporated, it afforded cryſtals, ſome of which were in tranſparent grains, others reſembled two pencils of rays diverging from one point. M. Butini has obſerved all the phænomena of that cryſtallization with greater accuracy. With the heat of a lamp which was very faint, he evaporated a ſolution containing nine grains of this ſalt to the ounce of water. A pellicle was ſoon formed on the ſurface, the under part of which, as well as the ſides of the veſſel, were in a manner fringed over with bunches of cryſtals. The reſidue exhibited bright needles, conſiſting of ſmall hemiſpherical maſſes with diverging threads. Theſe needles were not a line in length; but when viewed with a microſcope, appeared to be long priſms with ſix ſides, truncated by an hexagon, and reſembling certain ſpars.

M. Butini has likewiſe diſcovered another way of cryſtallizing magneſian carbonate. It conſiſts in expoſing to the air a ſolution of this ſalt precipitated by heat. At the end of a few days, this ſolution affords cryſtals reſembling thoſe which are obtained by evaporation. Magneſia precipitated from Epſom ſalt by carbonate of potaſh, and afterwards dried, will not cryſtallize in this manner; though diluted in water, it never forms any other than irregular lumps. But a ſolution of ſulphate of magneſia, taken ſoon after it has been precipitated by the ſame ſalt, gives, at the end of ſeveral days, cryſtals in the ſhape of needles.

When

When this ſolution is ſeparated by filtration from its precipitate, it likewiſe gives needles of magneſia. I have often obſerved, that a ſolution of carbonate of magneſia, prepared for the uſe of a laboratory, and kept in well ſtopped glaſs phials, depoſites, after ſome time, a large quantity of very fine bright ſmall needles, which, when viewed through a magnifier, appear to be priſms of ſix ſides.

Perfect neutral ſalts ſuffer no alteration from magneſian carbonates, nor do they produce any change upon it. Only, according to M. Butini, they render it more ſoluble in water. But carbonate of potaſh muſt here be excepted; for it rather deſtroys *its* ſolubility.

Effervcſcent magneſia decompoſes calcareous neutral ſalts; and this decompoſition is effected by virtue of a double affinity. We have already obſerved that lime has a greater affinity than magneſia with the acids, and of conſequence decompoſes neutral ſalts, which have magneſia for their baſe. It is to the acid, therefore, that the decompoſition of calcareous ſalts by magneſian carbonate is owing. Lime, on account of the ſtrong affinity which it has with the carbonic acid, forſakes the other acids to combine with it, provided the acids which it deſerts find another baſe with which they can enter into combination. Therefore, when a ſolution of magneſian carbonate is poured into a ſolution of calcareous ſulphate, nitrate, or muriate, the ſulphuric, the nitric, or the muriatic acid, forſaking the lime, combines with the magneſia to form ſulphate, nitrate, or muriate of magneſia; while the lime combining

bining with the carbonic acid ſeparated from the magneſia is precipitated in chalk.

Magneſia in this inſtance, therefore, reſembles ammoniac. When either of theſe ſubſtances is pure and cauſtic, it is incapable of decompoſing calcareous ſalts, as having a greater affinity than lime with the acids. But when united with the carbonic acid, and in the ſtate of neutral ſalts, they then acquire the power of decompoſing calcareous ſalts by double attraction; as has been already ſhown under the articles Sulphate of Lime, Calcareous Nitrate, &c.

The ſalt of which we are ſpeaking is uſed in medicine under the name of *mild or white magneſia*. It was formerly prepared from mother water of nitre, evaporated to dryneſs, or precipitated by fixed alkali. It was originally known by the name of *Count Palma's powder*, and *Sentinelli's powder*; It has ſince been called *laxative polychreſt ſalt by Valentini*, *white magneſia of nitre*, *magneſia of common ſalt*; becauſe it was obtained from the mother water of this laſt ſalt. But when prepared in this manner, it always contains calcareous earth, and various other extraneous matters; And therefore, what is at preſent made uſe of, is uſually precipitated from ſulphate of magneſia by vegetable fixed alkali, or carbonate of potaſh.

M. Butini gives an excellent proceſs for obtaining it very fine and in as large a quantity as poſſible. Dilute any quantity of potaſh in twice its weight of cold water; let this lixivium, if the ſeaſon will allow, be expoſed to the air for ſome months, in order that it may abſorb carbonic acid from the atmoſphere, and that the earth which it contains may be precipitated; let

it

it then be filtrated; next diſſolve a quantity of ſulphate of magneſia equal to the quantity of potaſh which you have already diſſolved, in water equal to four or five times its weight; filtrate this ſolution, and add a new quantity of water equal to five times the weight of the ſalt. Let this liquor be heated to ebullition, and then poured into the ſolution of vegetable alkali. The precipitate of magneſia is ſoon formed, and the mixture muſt then be well ſtirred, and afterwards filtrated through paper. The precipitate which remains on the paper uſed in the filtration muſt be waſhed with boiling water, to carry off the ſulphate of potaſh intermixed with it. After the water is ſufficiently drained off, the magneſia muſt be taken and ſpread on pieces of paper in thin layers, and put into a ſtove to dry. When thoroughly dried, it appears in the form of white lumps, which crumble between the fingers into a very fine powder that ſticks to the ſkin.

This magneſia, in combination with the carbonic acid, is to be preferred as a purgative; becauſe it is much more ſoluble. It is given in doſes of one or of two ounces, as the caſe requires. But cauſtic magneſia again is preferable to it as an abſorbent; and apothecaries ſhould keep both kinds. The principal reaſon for preferring ſometimes the one, ſometimes the other of theſe, in the practice of phyſic, on account of which apothecaries ought always to keep both kinds, has been very well explained by Macquer in a paper inſerted among thoſe of the Royal Society of Medicine. When magneſia is given as an abſorbent, the deſign of it is to deſtroy and neutralize an acid exiſting in too great abundance in the primary paſſages, as is the caſe with children, young girls, lying-in women, &c. This

gaſtric

gaſtric acid is certainly ſtronger than the carbonic. When mild magneſia, therefore, enters the ſtomach, it produces an effervescence, more or leſs lively according as there is more or leſs of the acid to be abſorbed in the primary paſſages. The carbonic acid diſengaged by this effervescence diſtends the ſtomach, and frequently occaſions pains, nauſea, vomitings, a difficulty of breathing, with many other ſpaſmodic complaints, according as the ſenſibility of the parts is greater or leſs. In ſuch caſes, therefore, it is much better to make uſe of pure magneſia, which abſorbs the ſour matter as powerfully, and occaſions no effervescence.

Again, when magneſia is given as a purgative, and not to abſorb acid matter in the primary paſſages, magneſian carbonate may then be given. The carbonic acid is not diſengaged in this caſe, and the complaints occaſioned by this elaſtic fluid diſtending the ſtomach are not to be feared. Phyſicians ought therefore to be acquainted with theſe two kinds of magneſia, and to know when the one and when the other is to be adminiſtered; and apothecaries ought always to keep both in their ſhops.

M. Bütini mentions an artificial mineral water, conſiſting of gazeous water impregnated with magneſia. He obſerves, that this fluid may be made to contain three drams of this magneſian earth to the pound; and that, beſides, it may be as eaſily prepared as acidulated or gaſeous martial waters. In fact, both are prepared preciſely in the ſame way. Phyſicians might find this water uſeful on many occaſions. *See my Memoirs on Magneſian Salts, in the Annals of Chemiſtry, ſecond and third volumes.*

CHAP.

CHAP. IX.

Genus V. *Argillaceous or Aluminous Neutral Salts.*

CLAY, or alumine, when very pure, combines very readily with moſt of the acids. From theſe combinations there reſult neutral ſalts, which are known by the general name of *argillaceous* or *aluminous ſalts*. Excepting the firſt ſpecies, no part of this genus of ſaline matters has yet been examined with proper care by chemiſts; and their properties are therefore ſtill leſs known than the properties of the ſalts belonging to the four preceding genera. Aluminous ſalts are in general more imperfect than any of the neutral ſalts which have hitherto engaged our attention. They yield their acids to the fixed alkalis, ammoniac, barytes, lime, and magneſia. They have a ſour aſtringent taſte.

This genus includes ſix ſpecies;—alum, or aluminous ſulphate; aluminous nitrate; aluminous muriate; aluminous borate; aluminous fluate; and aluminous carbonate.

Species

Species I. *Aluminous Sulphate or Alum.*

ALUM is a neutral ſalt, conſiſting of the ſulphuric acid combined with aluminous earth or pure clay, and it merits, of conſequence, the name of *aluminous ſulphate.* Chemiſts have not always agreed concerning the nature of the baſe of alum. Some formerly diſtinguiſhed it from clay, under the name of *aluminous earth* or *earth of alum.* Margraaf has ſhown that a mixture of this earth with ſilex, both in powder, forms clay. Hellot, Geoffroy, Pott, and more eſpecially M. Baumé, have all formed genuine alum by mixing clay with the ſulphuric acid. Laſtly, if the characteriſtic properties of clay be to form a tenacious paſte with water, and to ſhrink and harden when expoſed to fire; as aluminous earth diſplays theſe properties in an eminent degree, it is therefore to be conſidered as the pureſt part of clay. Such is the opinion which at preſent is generally prevalent among chemiſts concerning this matter. This ſhows ſtill more ſtrongly the propriety of diſtinguiſhing the earth which ſerves as the baſe of alum by the peculiar name of *alumine;* becauſe clay, however pure, always contains a portion of ſiliceous earth.

Aluminous ſulphate, or alum, at firſt affects the organs with a ſweetiſh taſte, and is afterwards felt to be ſtrongly aſtringent. It makes blue paper red; which ſhows it to contain a portion of unſaturated acid. It is capable of a very regular form, which will be deſcribed below.

Alum

Alum is ſcarce ever found in nature in a pure inſulated ſtate. Sometimes, however, it is found in places near volcanoes, but always mixed with clay. Mineralogiſts, particularly Wallerius, have taken notice of ſeveral ſpecies of native alum; ſuch as ſolid alum, cryſtallized alum, alum in an eſſloreſcence, white, grey, brown, and black, aluminous earths, and aluminous ſchiſti.

In commerce there are ſeveral kinds of alum known.

1. [illegible] or rock alum, in pretty large tranſparent maſſes. Bergman imagines it to derive this name from the city of Rocca in Syria, now called *Edeſſa*, in which the earlieſt manufactory of this ſalt was eſtabliſhed; not, as ſome writers would perſuade us, from its reſembling a rock, or from its being obtained from rocks; This ſpecies of is very impure.

2. Roman alum, which is prepared in the territory of Civita-Vecchia, and obtained from a place the Italian name of which is *Aluminiere della Tolfa.* This alum is in lumps of the ſize of eggs, and covered over with a reddiſh eſſloreſcence. It paſſes for pure when ſeparated from the eſſloreſcence.

3. Neapolitan alum, which is extracted at Solfatara from a particular earth. This alum is in larger lumps than the Roman, and one of its ſurfaces is covered over with pyramidical cryſtals.

4. Alum of Smyrna. The earlieſt manufactories of alum appear to have been eſtabliſhed in the neighbourhood of Smyrna and Conſtantinople. Some ſpecimens of it are ſhown in the cabinets of the curious.

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5. French alum. Alum of all fizes is prepared by various manufacturers in France, especially at Javel near Paris.

6. Alum may be extracted from efflorescent schisti and volcanic products. I have obtained it in a pretty large proportion from earth that was brought me out of Auvergne. This salt might be obtained from other substances of the same kind that are to be found in France; and this branch of trade might be thus taken out of the hands of strangers. Alum is likewise extracted from earths and stones, which are found to contain it in many parts of Germany, (in which it has been manufactured since the year 1544), in Spain, in England, in Sweden, and in almost all the countries of Europe.

Beckman, in a dissertation on the subject, inserted among the acts of Gottingen, enters very fully into the history of this salt, and the method of manufacturing it. It appears from his learned researches, that the people of the east were the first who prepared or extracted alum: for what the ancients, and particularly Pliny, called *chlton*, *trichites*, *calachites*, and which they appear to have confounded with alum, as well as the στυπτηρία of the Greeks, seems to have been rather martial sulphate or green copperas in various states. The Italians took a lease of the alum manufactories in the neighbourhood of Constantinople. About the year 1459, Bartholmew Perdix, or Pernix, discovered a mine of this salt in the Isle of Ischia. Nearly about the same time, John de Castro found another at Tolfa, and a great number of alum manufactories were soon established in Italy, more especially when Pope Pius II.

prohibited the importation of alum from the eaſt. The manufacture paſſed next into Spain, Germany, England, and Sweden, about the beginning of the ſeventeenth century, (V. Beckman).

Aluminous ſulphate is prepared by a variety of proceſſes, according to the country where it is manufactured, and the materials from which it is obtained. Bergman, who has written an excellent diſſertation on the ſubject, divides the matters uſed in preparing alum, and commonly known under the name of *alum ores*, into two kinds: thoſe in which this ſalt exiſts fully formed, and thoſe which contain only its conſtituent principles. No farther proceſs than a lixiviation, is requiſite to extract the alum from the firſt; and of this kind are the earth from which it is obtained at Solfaterra, and that which I have mentioned from Auvergne. At Solfaterra this earth is mixed with water, and put into caldrons of lead, partly ſunk in the ground. The natural heat of the earth contributes to the ſolution and cryſtallization of the alum; and it is purified by a ſecond cryſtallization. In the ſame manner might the earths of Auvergne, &c. be lixiviated, the waters evaporated in leaden veſſels, and the alum cryſtallized.

As to the natural ſubſtances which contain only the principles of aluminous ſulphate, theſe are much more common than the former; and a preliminary preparation is requiſite before a neutral ſalt can be obtained from them. Aluminous ſchiſti muſt be calcined, in order that the bitumen from which they derive their colour may be burnt, and that the pyritical part of the ſtone, which ſupplies the alum, may be decompoſed. Bergman aſſerts, that if this ſchiſtus be waſhed before being

being calcined, it gives not a particle of alum. Expoſure to the air produces the ſame effects on pure pyrites ſprinkled with water. The ſpontaneous decompoſition of theſe ſubſtances affords ſulphuric acid, which combines with the clay to form alum. Thoſe pyritous ſubſtances, when brought into a ſtate of efflorescence, are lixiviated with water; and, after being ſuffered to depoſite the iron which it contains, the lixivium is evaporated and put into caſks to cryſtallize. The ſalt falls to the bottom in large cryſtals. A ſtrong ſoapy lixivium is often made uſe of to facilitate the cryſtallization of the alum. This proceſs is followed in ſeveral manufactories: but alum obtained in this manner always contains more or leſs iron. That again which is extracted from ſtones in which it exiſts ready formed is always purer, ſuch as Roman alum, for inſtance. Alum manufactured by a direct combination of the ſulphuric acid with clay, is always mixed with a certain proportion of iron, as the coloured clay from which it is prepared is always impregnated with that metal*.

* *M. Chaptal* relates that, in his own alum manufactory, he has been accuſtomed to ſpread his clays, calcined and reduced to ſmall pieces, over the floors of his leaden chambers; and when they are in this condition, to apply to them ſulphuric acid (obtained from the combuſtion of ſulphur with ſal petre) in vapours; in which ſtate, the acid acts more powerfully upon the clay, than if it had been diluted in water. By this proceſs, the whole ſurface of the clays is within a few days converted into alum.

All the *common* operations of this manufacture may be reduced to theſe four;

1. The decompoſition of the mineral, ſpontaneouſly in the open air, or elſe by fire;

Aluminous ſulphate in a regular cryſtalline form is a perfect octohædron, conſiſting of two tetrahædral pyramids, with their baſes united. This form, however, varies according to the circumſtances of the cryſtallization; the octohædron is more or leſs truncated, irregular, pointed, or flattened. The angles are more or leſs complete, or cut away: the cryſtals are joined, and often enchaſed in each other by means of their pyramids. M. Romé de Liſle has very carefully deſcribed [illegible] varieties in the new edition of his Cryſtallography.

A gentle heat liquefies this ſalt: a good deal of aqueous vapour then exhales from it; and it ſwells into a large light maſs, rough, and full of cavities, all over its ſurface. Here, as well as in the inſtance of borate, this phænomenon is owing to the diſengagement of the water, the bubbles of which gradually raiſe and dilate the ſaline particles. Alum in this ſtate receives the name of *calcined alum*. It has loſt under the operation about half its weight. It is now ſomewhat altered, and reddens ſyrup of violets: its taſte is ſtronger, the acid not being ſo much in a latent ſtate as before. When diſſolved in water, it gives as a precipitate a ſmall portion of earth. It may be cauſed to cryſtallize; but it ſcarce ſwells at all when calcined a new, as M. Baumé has obſerved. By calcining

2. The lixiviation of the product obtained by the above proceſſes;

3. The evaporating of the lixivium in leaden cauldrons, to the proper point of concentration;

4. The refrigeration of the concentrated lixivium, in coolers; into which it is conveyed; till it be fixed into tetrahædral pyramids, joined together, by two and two, at the baſes. H.

ing alum in a machine for diſtillation, we obtain, firſt, phlegm, and afterwards towards the end of the operation the acid. But we cannot decompoſe it entirely; for Geoffroy expoſed a quantity of alum in a retort to a very intenſe fire during three days and three nights, without obſerving it to ſuffer any remarkable alteration. I am of opinion, however, that the changes which alum undergoes when long expoſed to the action of fire, have not yet been examined with ſufficient care.

Aluminous ſulphate efflores̃ces ſlightly, and loſes the water of its cryſtals when expoſed to the air. In cold water it is ſcarce ſoluble; for, according to M. Baumé, two pounds of cold water diſſolve no more than fourteen drams of alum*: but boiling water diſſolves a quantity equal to more than half its own weight. Eight ounces of the fluid in this ſtate are ſufficient to maintain five ounces of the ſalt in ſolution. It cryſtallizes readily by cooling. Its cryſtals ſeem to be a kind of triangular pyramids, with truncated angles, but are in reality pieces of octohædrons. Depoſited on threads in the middle of the ſolution, they form very regular octohædrons, whoſe pyramids are obliquely truncated.

Siliceous earth effects no diſcernible alteration on aluminous ſulphate. This ſalt may be made to unite with a larger quantity of aluminous earth than it ordinarily contains. M. Baumé has found, by experiments, that on ſuch an occaſion it acquires the characteriſtic properties of common clay. To ſaturate alum with

* According to Kirwan, alum requires 15 times its weight of water to diſſolve it. H.

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aluminous earth, a ſolution of the ſalt muſt be boiled with a portion of the earth pure, and the mixture heated till it loſe its ſtiptic taſte. If the combination be properly effected, it now acquires a mild, inſipid, earthy taſte. M. Baumé has obſerved, that when evaporated, it affords ſpangles reſembling mica. The Duke de Chaulnes having left a lixivium of this ſalt ſaturated with earth, expoſed for a conſiderable time to the air, found it to contain at the end of a few months regular cubic cryſtals. M. le Blanc likewiſe obtained this ſubſtance in cubic cryſtals by a ſimilar proceſs. It appears that alum once ſaturated with earth can never be reduced to the ſtate of pure alum.

Aluminous ſulphate may be decompoſed by barytes or magneſia, each of which has a greater affinity than aluminous earth with the ſulphuric acid. Barytic, or magneſian ſulphate, is the reſult of ſuch a decompoſition.

Lime-water poured into a ſolution of this ſalt precipitates the earth. Both the fixed alkalis and ammoniac decompoſe alum. Carbonate of potaſh, ſoda, ammoniac, lime, or magneſia, likewiſe ſeparates the aluminous earth from this ſalt; but if the precipitation be effected without heat, the precipitated earth ſeizes part of the carbonic acid. But I have obſerved, that when a ſolution of alum is mixed with a hot ſolution of any of the alkaline carbonates, the precipitation is attended with an effervescence, owing to the diſengagement of the carbonic acid.

Aluminous earth, when precipitated by any of theſe ſubſtances, ſubſides gradually and in flakes. If dried ſlowly,

ſlowly, it becomes very white; when expoſed to fire, it decrepitates like clays. A ſtrong heat renders it pretty hard: its bulk is at the ſame time greatly contracted. It does not melt, though expoſed even to ſo intenſe an heat as that of the burning-glaſs in the garden *de l' Infante*. So tenaciouſly does it retain its water, that the utmoſt force of fire is requiſite to ſeparate them entirely. With water it may be baked into a clammy paſte, that makes, when burnt, excellent porcelain. Aluminous earth poſſeſſes therefore all the diſtinguiſhing properties of argillaceous earths; and Macquer has very juſtly declared it to be the pureſt clay that can be procured.

We know not very well in what manner barytes, magneſia, lime, and the pure alkalis, act on aluminous earth. Probably theſe ſubſtances, eſpecially the laſt of them, would, with the help of fire, reduce it to a vitreous frit. M. Achard has made a ſeries of experiments which verify this conjecture. The colour, the tranſparency, the hardneſs, and indeed all the properties of thoſe ſubſtances, vary according to the proportions in which the principles of which they are formed have been mixed together; as we learn from a diſſertation by the above-mentioned chemiſt on the ſubject.

The ſulphuric acid readily diſſolves aluminous earth when it is cool and wet; but when dry, it diſſolves it not without conſiderable difficulty. Several ounces of this ſolution, taken together, afford cryſtals of alum, mixed with a few ſcales or ſpangles reſembling mica. And M. Baumé tells us, that when this experiment is performed in the ſmall way, only theſe ſcales, and

no alum, are obtained. Other acids likewiſe diſſolve this earth, forming with it ſalts which are but little known, but ſhall be mentioned in ſome following articles.

We know not how aluminous earth would act upon the neutral ſalts: but its moſt ſingular property is that of combining in an extraordinary proportion with aluminous ſulphate without communicating to it new properties; of which we have ſpoken above. M. Baumé, to whom we owe that diſcovery, boiled a ſolution of [illegible] a quantity of earth precipitated from this ſalt by one of the fixed alkalis; and the liquor diſſolved the earth with effervescence. When filtrated, it had no longer the taſte of alum, but taſted as hard water. It did not communicate a red colour to the tincture of turnſol, but it gave a green colour to ſyrup of violets. By ſpontaneous evaporation, it afforded a few cryſtals in ſoft ſcales reſembling mica. M. Baumé compares them to ſelenite, or ſulphate of lime. It is by no means eaſy to form alum by adding vitriolic acid to the ſalt thus ſaturated with earth; the mixture is now acid, but not ſtiptic: yet, by a ſpontaneous evaporation for three months, the ſolution afforded cryſtals of alum, mixed with ſome micaceous ſpangles, like thoſe which the alum ſaturated with earth afforded. Such is the reſult of the experiments of Meſſrs Macquer and Baumé on aluminous earth.

Alum, when expoſed to fire with combuſtible matters, forms a ſubſtance which kindles in the air, and is called *Homberg's pyrophorus*. That chemiſt, who made this combination known to the world in the year 1711, long laboured to obtain from the human faeces

a white oil, which he expected to fix mercury into fine ſilver. His laboars on this project gave riſe to ſeveral diſcoveries. The reſidue of that animal matter diſtilled with alum takes fire in the air. Homberg repeated this proceſs again and again, and it always ſucceeded. Lemery the younger, publiſhed in the years 1714 and 1715, two Memoirs, in which he informed the world that pyrophorus might be compoſed out of a great many vegetable and animal matters, treated with alum: but he did not ſucceed in forming it from ſome other ſulphuric ſalts. Thoſe two chemiſts, who conſidered alum as a combination of the ſulphuric acid with calcareous earth, thought that the calcareous earth, being reduced to the ſtate of lime, attracted moiſture from the air; and that the ſulphur, which they knew to be then formed, was inflamed by the heat then produced in the mixture.

Since the time of thoſe chemiſts, Le Jay de Suvigny, doctor in medicine, has given an excellent memoir on this pyrophorus, inſerted in the third volume of the *Memoires des Savans Etrangers.* In that paper he details a great many experiments, by which he at length effected the compoſition of pyrophorus, not only from alum with various combuſtible matters, which Lemery had effected, but even from moſt ſalts containing ſulphuric acid. That Chemiſt has likewiſe given a theory of the inflammation of pyrophorus when expoſed to the air, which has been unanimouſly adopted by later chemiſts. He takes pyrophorus to contain *glacial oil of vitriol*, which, by attracting moiſture from the air, and gradually heating the maſs, kindles the ſulphur, and occaſions a ſpontaneous evaporation.

Pyrophorus

Pyrophorus is uſually prepared by melting three parts of alum with one of ſugar, honey, or meal, in an iron ladle. This mixture is dried till it become blackiſh and ceaſe to ſwell. It is then broken into pieces, and put into a matraſs, or phial lured with earth; this veſſel is then put into a crucible containing ſand, and heat is applied till a bluiſh flame be ſeen to iſſue from the mouth of the phial. After ſuffering it to burn in this manner for a few minutes, the crucible is removed from the fire. Its contents are left to cool, and the pyrophorus is then poured into a dry flaſk, which admits of being very cloſely ſtopped. This pyrophorus takes fire on being expoſed to the air; and that the more readily in proportion as the atmoſphere contains a greater quantity of aqueous vapour. Its combuſtion may be accelerated by bringing it into contact with humid vapour, ſuch as the human breath. Pyrophorus, if too long expoſed to heat when it is compoſed, becomes incapable of taking fire in the air. When kept in a veſſel not cloſely ſtopped, it is gradually impregnated with moiſture, and loſes its tendency to combuſtion: but it may be reduced by calcining it anew, in the manner above deſcribed.

This was all that we knew of pyrophorus, before M. Prouſt's valuable experiments, of which he has given an account in the *Journal de Medicine* for July 1778. That chemiſt, in the courſe of his chemical operations, having met with a great number of pyrophoric reſidues, which he could not well ſuppoſe to contain any portion of ſulphuric acid, was induced to think that pyrophorus did not owe to that acid its ſpontaneous inflammation. By a very ſimple experiment, he has proved that it does not

not contain a ſingle particle of ſulphuric acid not in a latent ſtate; for, when water is poured on it, no heat is produced. The reſult of all his experiments and obſervations on this head is, that all ſubſtances which leave, on being decompoſed, a carbonaceous reſidue intermixed with an earth or a metallic oxide, are capable of ſpontaneous inflammation in the air. Yet we cannot avoid obſerving, that M. Prouſt, in that part of his reſearches on this matter which he has communicated to the public, does not explain the reaſon why Homberg's pyrophorus takes fire in the air; for, according to him, it is a ſubſtance entirely different from thoſe of which he gives an account. His memoir, indeed, ſays nothing at all of the pyrophorus which we have deſcribed above.

Mr Bewly, an Engliſh ſurgeon, in a letter addreſſed to Dr Prieſtley, aſcribes the inflammation of pyrophorus to its containing a ſubſtance capable of attracting nitric acid from the atmoſphere. What ſuggeſted this opinion to him was his diſcovering that ſpirit of nitre inſtantly inflames pyrophorus, though not ſufficiently calcined, or containing ſome portion of moiſture. But, in the firſt place, it is by no means certain that the atmoſphere naturally contains nitric acid: and again, M. Prouſt has diſcovered, that the inflammation of pyrophorus by ſpirit of nitre, is owing to the coal which it contains; for the nitric acid detonizes with all carbonaceous matters that are ſufficiently dry, and not too cloſely united by the force of aggregation; as we ſhall explain more at large when we come to the article of coal. Mr Bewly's explanation of this phænomenon

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is, therefore, not more ſatisfactory than thoſe of former chemiſts.

The only way by which we can hope to diſcover the cauſe of this phænomenon is, making ourſelves intimately acquainted with the nature of Homberg's pyrophorus. It appears to conſiſt of aluminous earth, a looſe carbonaceous matter, ſupplied by the honey or ſugar, &c. a little potaſh, and a ſmall portion of ſulphur, united partly with the aluminous earth and in part with the alkali. When pyrophprus is ſtrongly heated in a pneumato chemical machine, a large proportion of ſulphurated or *hepatic* hydrogenous gas is obtained from it. When it becomes incapable of furniſhing this ſubſtance, it is no longer ſuſceptible of inflammation in the air. Pyrophorus, immerſed in vital air, burns rapidly, giving out a very bright red flame. When waſhed with warm water, it affords a genuine *ſulphure*, leaving on the ſurface of the filter or ſtrainer carbonaceous matter with a little aluminous earth. The pyrophorus is then decompoſed. When pyrophorus ceaſes to burn, it is found to have acquired an increaſe of weight by abſorbing a portion of oxigene. If when in this ſtate it be lixiviated, it affords aluminous ſulphate; becauſe the ſulphur burnt by the action of the air forms ſulphuric acid which combines with the aluminous earth. But the ſalt thus obtained is alum ſaturated with earth.

The *Journal de Phyſique* for November 1780, contains ſome obſervations on pyrophorus, in which we are told, 1. That this ſubſtance owes its combuſtibility to its containing a certain quantity of phoſphorus formed by the acid of mucous matters. 2. That

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an ounce of pyrophorus gives, when diſtilled, from five to ſeven grains of pyrophorus. 3. That pyrophorus may be at any time readily compoſed by triturating fifty-four grains of flowers of ſulphur, thirty ſix of very dry charcoal of willows, and three of common phoſphorus, together in an iron mortar. The particulars of the analyſis do not exactly correſpond with the inductions deduced from it; for it does not appear that real pyrophorus was obtained. But the memoir contains a number of important facts, which it may be advantageous to any chemiſts, who ſhall hereafter attempt an analyſis of pyrophorus, to be acquainted with.

Alum is applied to many uſeful purpoſes. In medicine, it is uſed as an aſtringent: but it ſhould be very cautiouſly adminiſtered internally. It is oftener applied externally as a ſtiptic and a powerful deſiccative. It is uſed in gargles, plaſters, collyria, &c.

Few ſaline matters are of more uſe in the arts than alum. Chandlers mix it with their tallow, to render it more ſolid and conſiſtent. Printers rub their balls with calcined alum, to make them take up the ink. Wood impregnated with a ſolution of alum will ſcarcely burn. And the uſe of alum has therefore been propoſed to ſecure houſes from taking fire. It produces the ſame effects on paper as on wood. But paper impregnated with alum ſoon becomes yellow, and ſuffers an alteration of nature.

Bleachers put a little alum into muddy water to purify it. M. Baumé thinks, that on this occaſion the ſalt attracts to it part of the earth ſuſpended in the fluid, and that the earth and the ſalt forming an inſo-

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luble compound, are precipitated together. Some people uſe alum to purify water which they are to drink. It is uſed in preparing leather; and cloth and paper, on which colours are to be impreſſed, are firſt impregnated with alum.

A ſolution of alum retards the putrefaction of animal ſubſtances. This is an excellent, and a very cheap way of preſerving natural productions which are ſent as ſpecimens from one country into another. Aluminous earth conſtitutes the baſe or body of paſtils or crayons. And, laſtly, this ſalt is, as Macquer ſays, the very ſoul of the art of dyeing. It renders colours deeper and more bright, and it confers ſolidity on the particles of colouring matters; without the help of alum no colour would be permanent or proof againſt water. This property of alum will be examined when we come to ſpeak of colouring vegetable matters. We ſhall then ſee that alum renders them permanent by changing their nature, decompoſing them, and making them inſoluble in water*.

Species II. *Aluminous Nitrate.*

M. Baumé ſays, that the nitric acid entirely diſſolves aluminous earth. This ſolution is limpid, and much more aſtringent than a ſolution of alum. By ſpontaneous evaporation, it gives ſmall pyramidal cryſtals, extremely ſiptic, and liable to deliquiate.

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* Alum is alſo employed in a preparation of glue for the deſtruction of inſects. It is uſed by the bakers of *England* and other places, to improve the whiteneſs, and increaſe the weight of their bread. H.

The other properties of this ſalt have not yet been examined; only, we know that it admits of decompoſition by the intervention of the ſame ſubſtances which decompoſe alum. It has not yet been found in nature, but is always a product of art.

Species III. *Aluminous Muriate.*

The muriatic acid diſſolves aluminous earth better than the nitric acid. This ſolution, when the ſubſtances are mutually ſaturated, is gelatinous, nor can it be filtrated without being diluted in a great deal of water. Aluminous muriate has a ſaline ſtiptic taſte; it firſt reddens ſyrup of violets, and afterwards converts the red colour to a green. By ſpontaneous evaporation it gives very ſtiptic cryſtals, the form of which has not yet been examined: lime-water decompoſes them. Aluminous muriate is liable to deliquiate. It has never yet been obtained but by the manipulations of art. Its other properties are unknown.

Species IV. *Aluminous Borate.*

The combination of the boracic acid with aluminous earth, which we call *aluminous borate*, has not as yet been examined. We know that when a ſolution of borate of ſoda is poured into a ſolution of aluminous ſulphate, it produces a light flaky precipitate. The ſulphuric acid forſakes the aluminous earth, in order to combine with the ſoda. The earth again combines with

with the boracic acid, which is ſeparated at the ſame time. And this new ſalt is by degrees diſſolved again. The liquor thus precipitated by the fixed alkali, gives by evaporation a viſcid aſtringent maſs, conſiſting of ſulphate of ſoda and aluminous borate confounded together. This kind of borate may be decompoſed in the ſame manner as alum; but its properties have not yet been examined with ſufficient care.

Species V. *Aluminous Fluate.*

We give this name to the combination of the fluoric acid with aluminous earth. This neutral ſalt is not known, and has never been examined. Scheele, Boullanger, and Bergman, have ſaid nothing about it.

Species VI. *Aluminous Carbonate.*

The combination of the carbonic acid with aluminous earth has been as yet but very little examined. It is certain, however, that the carbonic acid admits of combination with aluminous earth: For, 1. As Bergman has remarked, when a ſolution of alum is precipitated by the alkaline carbonates, the filtrated liquor depoſites, at the end of ſome time, a little earth which was held in ſolution by the carbonic acid, and is left in a ſeparate ſtate, as the acid gradually eſcapes. 2. This precipitation, when the matters are cold, takes place without any effervescence, and part of the carbonic acid ſeparated by the alkali, appears to enter into com-

bination with the aluminous earth, while another part is diſſolved in the liquor.

Beſides, from the decompoſition of many argillaceous earths by ſeveral modern chemiſts, it is at preſent known that they contain carbonic acid; for, when diſſolved in the ſulphuric and the muriatic acids, they always effervesce either more or leſs*.

* *Schreber*; and after him *Chaptal*, and *Schmeiſſer*; aſſert, that the milk-white, friable earth, known by the name of *Lac Lunæ*, is, in part, an aluminous carbonate. H.

CHAP. X.

Genus VI. *Barytic Neutral Salts, or Neutral Salts with a Baſe of Barytes.*

BARYTES in combination with the acids forms a claſs of neutral ſalts, which differ from thoſe which we have hitherto been examining, in form, taſte, ſolubility, and in the laws of their decompoſition. This earthy-alkaline ſubſtance has a greater affinity with the acids than any of the three alkalis, or of the other earths. Theſe alkaline ſubſtances muſt be united with the carbonic acid, to enable them to decompoſe barytic ſalts. Theſe ſalts are ſix in number, namely, barytic ſulphate or ponderous ſpar, barytic nitrate, barytic muriate, barytic borate, barytic fluate, and barytic carbonate. To theſe ſix we may add the combinations of barytes with the tunſtic, the arſenic, the molybdic, and the ſuccinic acids; but as theſe are not much known,

known, we ſhall defer ſpeaking of them till we come to the hiſtory of the four acids to which they owe their formation.

Species I. *Barytic Sulphate, or Ponderous Spar.*

Ponderous ſpar, which being inſipid and inſoluble, has been hitherto conſidered by naturaliſts as a ſtone, is produced by the combination of the ſulphuric acid with barytes, and ſhould therefore be called *barytic ſulphate*. This earthy ſalt has been by many naturaliſts confounded with *fluor ſpar*, or calcareous fluate: both indeed have the ſame fracture, and effervesce in the ſame manner with acids. But the form, the obſcurity, and the ponderoſity of *ponderous ſpar*, plainly diſtinguiſh it from the other. Beſides, it poſſeſſes one chemical quality, which alone might be ſufficient to peculiarize its character. If a ſmall portion of ſulphuric acid be poured on powder of ponderous ſpar, the acid moiſtens the ſpar without diſengaging from it any vapour, or cauſing it to exhale any ſmell; whereas calcareous fluate, or *fluor ſpar*, when treated in the ſame manner, exhales by degrees a gas of a poignant ſmell, which, on coming into contact with air, compoſes a white ſmoke that is ſoon perceived to be fluoric acid. Other naturaliſts have confounded it with *ſcheelitous ſpar*; but this ſubſtance again is of a different form, and more ſoluble, and may be decompoſed by the fixed alkalis in a pure or cauſtic ſtate; whereas theſe ſalts effect no alteration on ponderous ſpar.

Barytic

Barytic ſulphate abounds in nature. It is almoſt always found along with metallic ores. It appears either in cryſtals or in ſhapeleſs maſſes, but is always diſpoſed in layers which vary in thickneſs and extent. It is pretty hard, yet does not give fire with ſteel. The following are its principal varieties.

Varieties.

1. Barytic ſulphate, or *ponderous ſpar*, white, ſemi-tranſparent, and cryſtallized in priſms, of ſix ſides, two of them very large, and the other four very little, terminating in dihædral ſummits. Theſe cryſtals are diſpoſed in an oblique poſture, on maſſes of the ſame nature with themſelves. They reſemble oblong ſquare plates, the four ſides of which have been cut obliquely. They are often covered with yellowiſh rhomboidal cryſtals. This, as well as the following ſpecies, is called *ponderous ſpar in tables*.
2. Barytic ſulphate, or *milk-white ponderous ſpar*, in tables, but not having the ſides cut aſſant. It is not regularly cryſtallized, but is found in tolerably thick layers, arranged one over another. It is often incruſted with a red duſt, of reddiſh ſilver ore, or *pyrites*.
3. Round, *ſemi-chatoyant*, barytic ſulphate or *ponderous ſpar*: Bologna ſtone. It conſiſts of a number of converging filaments united into laminæ, arranged one over another. This variety is better known than any of the others, on account of its being phoſphoric. It plainly

Varieties.

ly appears to have been agitated and worn by water.

4. Octohædral barytic ſulphate or *ponderous ſpar.* It cryſtallizes like alum. The ſummits of the pyramids are often truncated, ſo as to form a decahædral figure. It exhibits a number of other varieties, according as its angles are prolonged or truncated.
5. Duodecahædral barytic ſulphate or *ponderous ſpar.* It is of the form of certain garnets and ſome pyritous ſtones. It is ſeldomer to be met with than the preceding ſpecies.
6. Pyramidal barytic ſulphate, or ponderous ſpar. Both this and the preceding variety appear in M. Daubenton's table*.

I conſider as a variety of *ponderous ſpar*, that ſubſtance which is known by the name of *pearl ſpar*, and was formerly, as well as moſt of the preceding varieties, ranked among the *ſelenitous ſpars*. This ſpar conſiſts of ſmall rhomboidal ſcales, which are generally ſparkling, and obliquely diſpoſed one over another. It is opaque, brilliant, ſeemingly micaceous, and ſcattered over calcareous ſpar, quartz, or the firſt of the varieties above deſcribed. It is of a yellow or a dirty green colour, ſometimes of a ſilver white. The Abbé Haüy thinks it to be a genuine calcareous ſpar.

Margraaf, who examined ſeveral varieties of barytic ſulphate, ſuch as Bologna ſtone and white opaque

* Kirwan's *families* of the ſpecies of barytic ſulphate, in the 2d edit. of his Mineralogy, differ ſo much from the above varieties, as to prove that the native varieties of this ſalt are as yet but imperfectly known. H.

ponderous ſpar, imagined it to be a kind of *ſelenite* or calcareous ſulphate, mixed with a little clay, which rendered it inſoluble. But Gahn, Scheele, and Bergman, found it to be that peculiar earth to which we have given the name of *barytes*. M. Monnet has likewiſe found, by examining the ſalts which it forms with acids, that its baſe is of a different nature from calcareous earth; but he imagines it to contain ſulphur ready formed, and takes *ponderous ſpar* to be an earthy *liver of ſulphur* in cryſtals.

Barytic ſulphate, when expoſed to a violent heat, ſuch as that of a porcelain furnace, &c., melts into a glaſs more or leſs coloured. When expoſed to a moderate heat, it ſuffers no alteration. If carried into the dark, after being expoſed for a little to a ſtrong heat, it exhibits a very lively bluiſh light. Lemery tells us, that an Italian ſhoemaker, named Vincenzo Caſciarolo, was the firſt who diſcovered the phoſphoric quality of the Bologna ſtone. Finding a ſtone of this kind at the foot of Mount Paterno, its brightneſs and gravity made him think it contained ſilver. He expoſed it to fire, in order no doubt to extract from it if poſſible the precious metal, and obſerved, that when heated it gave light in the dark. Struck with the diſcovery, he repeated the experiment, and it conſtantly ſucceeded with him. A number of chemiſts and naturaliſts have ſucceſſively directed their attention to this phænomenon, and have calcined Bologna ſtone in all the various ways they could contrive. The works of Peterie, Montalbon, Mentzel, and Lemery, and the memoirs of Homberg, Duſay, and Margraaf, contain a variety of proceſſes for performing this operation.

This

This property is at preſent known to be common to all the varieties of barytic ſulphate. They are made red hot in a crucible, beaten in a glaſs mortar to a powder, formed into a paſte with a little gum tragacanth, and divided into cakes of the thickneſs of a knife blade. Theſe cakes are dried, and expoſed to a violent calcination among coals in a ſtrong drawing furnace; nor are they taken out till the coals be entirely conſumed and the furnace cold. The aſhes are then blown off them with a pair of bellows; they are expoſed to the light for a few minutes; and after this, when taken into the dark, they ſhine like a burning coal. Even in water they emit the ſame ſparkling light, but gradually loſe the property; which they regain, however, on being heated anew. But many ſubſtances diſplay the ſame phænomenon. Magneſia, chalk, calcareous ſulphate, and calcareous fluate, &c. become luminous, after being heated. Macquer has obſerved the exiſtence of the ſame property in earth of alum, ſulphate of potaſh, Briançon chalk, and black gun-ſtone calcined:—from which it appears that the preſence of an acid is not abſolutely neceſſary to the production of this phænomenon. Yet ſubſtances poſſeſſing an acid, diſplay it in a more eminent degree than others.

Margraaf could obtain no product by heating barytic ſulphate. The ſubſtance, he found, ſuffered no alteration.

This ſalt is abſolutely inſoluble in water. The earthy and the ſalino-terrene matters act not upon it. The pure fixed alkalis do not decompoſe it; which is the moſt ſingular of all its properties. All the other earths and ſalino-terrene matters have a weaker affi-

nity than the fixed alkalis with the ſulphuric acid. But barytes has a ſtronger affinity with the acids than thoſe ſalts. We have therefore obſerved, after Bergman, that this decompoſes both ſulphate of potaſh and ſulphate of ſoda. It has the ſame influence on ammoniacal ſulphate.

The mineral acids cannot act on barytic ſulphate; for the ſulphuric acid adheres with greater force than any of them to the earthy baſe of this ſalt. The neutral ſalts, excepting carbonate of potaſh and of ſoda, are equally incapable of acting upon barytic ſulphate. Theſe two ſaline ſubſtances, however, decompoſe it by double affinity. The barytes is ſeparated from the ſulphuric, becauſe it is attracted by the carbonic acid; while the fixed alkali acts with equal force on the ſulphuric acid. This decompoſition is effected by expoſing to a ſtrong heat in a crucible, a mixture conſiſting of two parts of carbonate of potaſh and one of barytic ſulphate in powder. This matter, after being half vitrified by the heat, is lixiviated in diſtilled water. The liquor is filtered, and then affords, by evaporation, ſulphate of potaſh. The matter which remains on the filter is barytic carbonate. After being well waſhed, it appears in the form of very white fine pulverulent matter, but is almoſt always contaminated with a portion of barytic ſulphate, which has eſcaped decompoſition.

As combuſtible bodies are capable of decompoſing this ſalt, we may make uſe of them when we wiſh to obtain its baſe ſeparate. When a powder of this ſalt, mixed with a portion of coal equal to an eighth part of its weight, has been expoſed to fire in a crucible,

cible, for two or three hours after the crucible became red hot,—if the matter be afterwards poured into diſtilled water, it will inſtantaneouſly communicate to the fluid a reddiſh yellow colour, with all the characteriſtics of a ſolution of earthy *ſulphure*: for the coal robs the ſulphuric acid of its oxigene, and the ſulphur being of conſequence left ſeparate, combines with the barytes, and is thus reduced to *ſulphure* or *hepar*. This ſolution of ſulphure may be precipitated by an acid. The muriatic acid is preferred for this purpoſe, becauſe it combines with the earth to form a ſoluble ſalt; whereas the ſulphuric acid would form barytic ſulphate, which is inſoluble. The liquor is next filtered. The ſulphur ſeparated by the acid remains on the filter; and the water which has paſſed through it holds the barytic muriate in a ſtate of ſolution. This ſolution again may be decompoſed by a ſolution of carbonate of potaſh: the barytes, combining with the carbonic acid, is precipitated; and theſe two principles may be again ſeparated by calcination, as we ſhall ſhow under a different article. This proceſs, which I have often performed, gives but very little barytes; and we find on the filter through which the ſolution of the *hepar* has been cauſed to paſs, after being precipitated by the muriatic acid,—nothing but a few particles of ſulphur, unleſs it be expoſed to a very violent heat. To promote the decompoſition of this earthy ſalt, Bergman and Scheele have directed about a fourth part of *fixed ſalt of tartar* to be added to the mixture of barytic ſulphate and coal. The ſulphur and the barytes are then eaſier ſeparated; becauſe the fixed alkali cauſes the matters to ſuffer a more complete fuſion.

From

From theſe two proceſſes for decompoſing barytic ſulphate, as well as from a view of its properties in general, it appears that the earth or ſalino-terrene ſubſtance, which is the baſe of this ſalt, is of a peculiar nature, differing from aluminous earth, lime, and magneſia.

Barytic ſulphate is of ſome uſe in the arts. Phoſphoric cakes are prepared of it, and the barytes which it contains is extracted for the uſe of chemical laboratories.

Species II. *Barytic Nitrate.*

The nitric acid combines readily with barytes. The reſult of the combination is a neutral ſalt, in large hexagonal cryſtals, or ſmall irregular cryſtals, according to M. d'Arcet. It is with great difficulty that we obtain it in cryſtals.

Barytic nitrate is decompoſed by the action of fire, and gives out vital air.

It attracts the moiſture of the atmoſphere. A conſiderable quantity of water, however, is requiſite to maintain it in ſolution.

Neither the pure alkalis, ſand, alumines, lime, nor magneſia, decompoſes it.

Sulphuric acid poured into a ſolution of barytic nitrate, immediately produces a precipitate of barytic ſulphate. The fluoric acid, too, robs this ſalt of its baſe.

Alkaline carbonate decompoſes it by a double affinity.

This ſalt is but very little known.

Species

Species III. *Barytic Muriate.*

This ſalt has been as little examined as the preceding. Bergman ſays that it is ſuſceptible of cryſtallization, and does not diſſolve eaſily. It may indeed be obtained in oblong ſquare cryſtals, pretty much like thoſe of ponderous ſpar in tables.

It is liable to no alteration or decompoſition from ſand, aluminous earth, magneſia, or cauſtic alkali.

The ſulphuric and the fluoric acids decompoſe this ſalt by combining with its baſe.

Carbonate of potaſh or of ſoda precipitates the barytes in combination with the carbonic acid.

Bergman reckons barytic muriate to be one of the moſt ſenſible re-agents, and propoſes to detect, by means of it, even the ſmalleſt portion of ſulphuric acid that can poſſibly be contained in any mineral water. If a drop or two of a ſolution of this ſalt be poured into about three pounds of water, containing twelve grains of ſulphate of ſoda in cryſtals, it will immediately produce barytic ſulphate in white ſtriæ, owing to the decompoſition of both the ſalts, and the union of the ſulphuric acid with the barytes. A portion of muriate of ſoda remains diſſolved in the liquor. All ſulphuric ſalts are equally affected by this re-agent; which always decompoſes them to form barytic ſulphate.

Species IV. *Barytic Borate.*

This combination of the boracic acid with barytes is entirely unknown. Bergman aſſerts that the acid of

of borax is among thoſe which have the leaſt affinity with the ſalino-terrene ſubſtances, and ranks it in his table below moſt of the vegetable and animal acids.

Species V. *Barytic Fluate.*

This ſalt is as little known as the preceding; and with many other ſaline matters that have not yet been examined, and on which we are therefore obliged to be very brief, affords matter for new experiments.

Bergman, in his diſſertation on elective attractions, aſſerts, that when fluoric acid is poured into a ſolution of barytic nitrate or muriate, it occaſions a precipitation; and that the precipitate thus produced effervesces with the ſulphuric acid, which expels the fluoric from it.

This inſtance proves the fluoric acid to have a greater affinity with barytes than either the nitric or the muriatic acid; and ſhows, that it forms, with this ſalino terrene ſubſtance, a ſalt much leſs ſoluble than barytic nitrate or barytic muriate.

Species VI. *Barytic Carbonate.*

Barytes combines with the carbonic acid to form a neutral ſalt poſſeſſed of ſome ſingular properties, and appearing to bear ſome relation to chalk.

We have already obſerved, that it is in conſequence of the affinity ſubſiſting between barytes and the carbonic

bonic acid, that barytic ſulphate, and all barytic ſalts in general, are decompoſed by alkaline carbonate. In theſe inſtances, barytic carbonate is always precipitated. This ſalt is likewiſe prepared by expoſing to the air a ſolution of pure baryles. The ſurface of the liquor is gradually covered with a pellicle, which effervesces with acids, in conſequence of the earth's being impregnated with carbonic acid from the atmoſphere, and becoming thereby leſs ſoluble. This phænomenon reſembles that which is exhibited by lime-water; and though barytes and lime differ widely in many of their other properties, yet here is a ſtriking analogy between them.

Barytic carbonate loſes its acid when expoſed to fire. If heated in a retort or matras fitted to a pneumato-chemical machine, it gives the acid in its natural gaſeous form. Yet it is exceedingly difficult to ſeparate the acid entirely, and a very intenſe heat is requiſite for the purpoſe.

All the mineral acids decompoſe this ſalt, and diſengage the carbonic acid. A lively effervesence is always produced on the occaſion, which diſtinguiſhes this ſalt from pure or cauſtic barytes. Bergman reckons an hundred weight of this ſalt to contain ſeven parts of carbonic acid, ſixty-five of barytes, and eight of water.

Water will ſcarce diſſolve barytic carbonate; but when it is itſelf impregnated with carbonic acid, it diſſolves a portion of this ſalt equal to an 1550th part of its own weight. From this it appears that barytic carbonate is ſtill more difficult of ſolution than pure or cauſtic barytes: for, according to Bergman, water

diſſolves

diſſolves about a 900th part of pure barytes. This ſalt therefore appears, in this inſtance, to be ſubject nearly to the ſame laws with chalk or carbonate of lime, and like it is precipitated when the carbonic acid evaporates from the water which maintained it in ſolution. But in other reſpects there is a wide difference between them. The ſalts which barytes forms with other acids, ſhow, as we have above obſerved, that it differs eſſentially from lime.

Barytic carbonate is of no uſe. It is found in nature*.

CHAP.

* Barytic carbonate has been found in nature, on Alſton moor, in Cumberland; and in the lead-mine of Anglefark, in Lancaſhire. Its texture is ſtriated; its ſpecific gravity, 4, 331. Its colour is a greyiſh white: It is found in ſolid maſſes, frequently rounded, but rarely cryſtallized. Its fracture is partly fibrous, partly conchoidal; Its fragments are long and ſplintery: Its luſtre is as 2: Its tranſparency, 2, 3: Its hardneſs from 5 to 6 of Kirwan's eſtimate. It has been lately found in Argyleſhire; or Schlangenberg in Siberia; and in the pit of Iſaacfund near Freyberg in Saxony. H.

CHAP. XI.

Recapitulation and Compariſon of the Mineral Salts.

AFTER the above account of the preſent ſtate of chemical knowledge reſpecting the properties of mineral ſalts, it may next be proper to take a brief comparative view of the principal characteriſtics, and the mutual affinities of theſe bodies.

I. Salts are diſtinguiſhed by four general properties; taſte, tendency to combination, ſolubility, and incombuſtibility. Theſe properties exiſt in various degrees of energy; and the various degrees of their energy conſtitute the eſſential differences which diverſify ſaline matters.

II. All ſalts may be arranged under four orders or four principal genera. 1. Salino-terrene ſubſtances, which poſſeſs the properties of both earths and ſalts. 2. Alkalis, the characteriſtics of which are, an urinous taſte, and the property of converting many blue vegetable colours to green. 3. Acids, diſtinguiſhed from

other

other ſalts by their ſour taſte, and by communicating a red colour to blue vegetable matters. 4. Middle or neutral ſalts, which differ from the preceding, as being of a weaker, but a mixed ſaline bitter taſte, and being leſs ſoluble, &c.

III. There are three ſalino-terrene ſubſtances; ponderous earth or baryres, magneſia, and lime. Their properties are pretty well known; but of their component principles we are ignorant. No chemiſt has hitherto ſeparated any of theſe bodies into diſtinct principles, or formed them by combination. They are, therefore, actually ſimple in reſpect to the preſent ſtate of the ſcience. But they may, one day, perhaps be decompoſed.

IV. We know of three alkalis; potaſh, called alſo *vegetable fixed alkali* and *alkali of tartar*; ſoda, likewiſe known under the name of *mineral alkali* or *marine alkali*; ammoniac or volatile alkali. The two firſt of theſe are dry, ſolid, cauſtic, fuſible, liable to deliquiate, &c. When pure, it is impoſſible to diſtinguiſh between them; but they are readily diſcriminated by the manner in which they combine with acids. Hitherto we have obtained no certain experimental knowledge of their intimate compoſition: No perſon has yet ſeparated them into principles, or formed them by combination.

The opinion which repreſents them as compounds of earth and water, is nothing more than an ingenious fancy, which muſt be given up becauſe it is ſupported by no poſitive facts. Ammoniac differs from them in appearing under the form of an claſtic fluid, ſtrongly odorous, and ſuſceptible of an amazing expanſion, &c.

It

It is at preſent known to conſiſt of the baſes of two gaſeous ſubſtances,—inflammable gas or hydrogene, and atmoſpheric mephitis or azote. It is decompoſed on ſome occaſions, and on others formed by combination. It appears that the two fixed alkalis likewiſe contain azote, and that this ſubſtance may be conſidered as the alkalifying or alkaligenous principle.

V. There are ſix acids with which we are well acquainted; the carbonic, the muriatic, the fluoric, the nitric, the ſulphuric, and the boracic acids. Each of theſe is diſtinguiſhed by its peculiar properties. The carbonic, the muriatic, and the fluoric acids, are very eaſily made to aſſume the elaſtic or aeriform ſtate. The caſe is not the ſame with the nitric and the ſulphuric acids. The boracic acid is concrete and cryſtalline. The arſenic, the molybdic, and the tunſtic acids, of which we are to ſpeak in a kind of appendix to this part, are concrete, but pulverulent, and never cryſtalline.

VI. We are now beginning to underſtand the nature of the acids much better than formerly. The hypotheſis which repreſented them as compounds of earth and water has been demonſtrated to be quite improbable. The oxigenous principle, which is the baſe of vital air, is known to enter for one principle into their compoſition. And an acid is often formed by the union of oxigene with ſome combuſtible ſubſtance; with coal, in the carbonic acid; with ſulphur, in the ſulphuric; and with azote, in the nitric acid. Another fact which concurs to prove that oxigene is a conſtituent principle in acids, is, the formation of a great many peculiar acids by the action of the nitric acid on combuſtible bodies.

VII. The acids unite, without ſuffering decompoſition, with alumine barytes, magneſia, lime, the fixed alkalis, and ammoniac. From theſe combinations there reſult a great many neutral ſalts, which are called *compound*, *middle*, or *neutral*. The ſubſtances which in theſe ſaline combinations neutralize the acids, are called *baſes*.

VIII. The properties of the middle or neutral ſalts are different from thoſe of their component principles; in moſt of them it is impoſſible to recognize any of the properties of either the acid or the baſe. The baſe, however, appears to communicate ſome general or common properties to neutral ſalts; for which reaſon we have claſſed them into genera by their baſes.

IX. On this principle there are ſix genera of neutral ſalts, the order, the compoſition, and the nomenclature of which, it may here be proper to lay again before the reader.

Genus I. *Neutral Salts, with a baſe of Fixed Alkali.*

Species.	Ancient Names.
1. The ſulphuric acid with potaſh.	
SULPHATE OF POTASH.	*Vitriolated tartar, ſal de duobus, arcanum duplicatum, vitriol of potaſh.*
II. The ſulphuric acid with ſoda.	
SULPHATE OF SODA.	*Glauber ſalt, vitriol of ſoda.*
III. The nitric acid with potaſh.	
NITRATE OF POTASH.	*Common nitre, ſaltpetre*

IV. The

Species.	Ancient Names
IV. The nitric acid with ſoda.	
NITRATE OF SODA.	*Cubic nitre, rhomboidal nitre.*
V. The muriatic acid with potaſh.	
MURIATE OF POTASH.	*Digeſtive ſalt, febrifuge ſalt of Sylvius, regenerated marine ſalt.*
VI. The muriatic acid with ſoda.	
MURIATE OF SODA.	*Marine ſalt, ſea ſalt, common ſalt, kitchen ſalt.*
VII. The boracic acid with potaſh.	
BORATE OF POTASH.	*Vegetable borax.*
VIII. The boracic acid with ſoda.	
SUPERSATURATED BORATE OF SODA, *or* BORAX.	*Common borax, tinck....*
IX. The fluoric acid with potaſh.	
FLUATE OF POTASH	*Spathoſe tartar. Spar of tartar*
X. The fluoric acid with ſoda.	
FLUATE OF SODA.	*Sparry ſoda.*
XI. The carbonic acid with potaſh.	
CARBONATE OF POTASH.	*Cretaceous tartar. Chalk of potaſh.*
XII. The carbonic acid with ſoda.	
CARBONATE OF SODA.	*Cretaceous ſoda. Chalk of ſoda.*

Genus II. *Ammoniacal Neutral Salts.*

Species.	Antient Names.
I. The ſulphuric acid with ammoniac.	
AMMONIACAL SULPHATE.	*Glauber's ſecret ammoniacal ſalt, ammoniacal vitriol.*

Species.	Ancient Names.
II. The nitric acid with ammoniac.	
AMMONIACAL NITRATE.	*Ammoniacal nitre.*
III. The muriatic acid with ammoniac.	
AMMONIACAL MURIATE.	*Sal ammoniac.*
IV. The fluoric acid with ammoniac	
AMMONIACAL FLUATE.	
V. The boracic acid with ammoniac.	
AMMONIACAL BORATE.	
VI. The carbonic acid with ammoniac.	
AMMONIACAL CARBONATE.	*English sal volatile.* *Concrete volatile alkali.* *Ammoniacal chalk.*

Genus III. *Calcareous Neutral Salts.*

Species.	Ancient Names.
I. The sulphuric acid with lime.	
CALCAREOUS SULPHATE.	*Plaster.* *Gypsum.* *Selenite.* *Calcareous vitriol.*
II. The nitric acid with lime.	
CALCAREOUS NITRATE.	*Calcareous nitre.*
III. The muriatic acid with lime.	
CALCAREOUS MURIATE.	*Fixed sal ammoniac, oil of lime.* *Calcareous marine salt.*

IV. The

Species.	Ancient Names.
IV. The fluoric acid with lime.	
CALCAREOUS FLUATE.	*Cubic ſpar, vitreous ſpar, fuſible ſpar or fluor, ſparry fluor, fluorated lime.*
V. The boracic acid with lime.	
CALCAREOUS BORATE.	
VI. The carbonic acid with lime.	
CARBONATE OF LIME.	*Chalk, calcareous ſpar, calcareous earth.*

Genus IV. *Magneſian Neutral Salts.*

Species.	Ancient Names.
I. The ſulphuric acid with magneſia.	
MAGNESIAN SULPHATE.	*Salt of Epſom or Sedlitz, bitter cathartic ſalt, vitrial of magneſia.*
II. The nitric acid with magneſia.	
MAGNESIAN NITRATE.	
III. The muriatic acid with magneſia.	
MAGNESIAN MURIATE.	*Marine ſalt, with a baſe of magneſia.*
IV. The fluoric acid with magneſia.	
MAGNESIAN FLUATE.	
V. The boracic acid with magneſia.	
MAGNESIAN BORATE.	
VI. The carbonic acid with magneſia.	
MAGNESIAN CARBONATE.	*Effervеſcent magneſia. Mild, aerated magneſia. Magneſian chalk.*

Genus V. *Aluminous Neutral Salts.*

Species.	Ancient Names.
I. The fulphuric acid with aluminous earth.	
ALUMINOUS SULPHATE.	*Alum, vitriol of clay.*
II. The nitric acid with aluminous earth.	
ALUMINOUS NITRATE.	*Argillaceous nitre.* / *Nitreous alum.*
III. The muriatic acid with aluminous earth.	
ALUMINOUS MURIATE.	*Argillaceous marine falt.* / *Marine alum.*
IV. The fluoric acid with aluminous earth.	
ALUMINOUS FLUATE.	*Sparry clay.* / *Argillaceous fluor.*
V. The boracic acid with aluminous earth.	
ALUMINOUS BORATE.	*Argillaceous borax.*
VI. The carbonic acid with aluminous earth.	
ALUMINOUS CARBONATE.	*Effervefcent clay.* / *Argillaceous chalk.*

Genus VI. *Neutral Salts, with a Baſe of Barytes, or Barytic Neutral Salts.*

Species.	Antient Names.
I. The fulphuric acid with barytes.	
BARYTIC SULPHATE.	*Ponderous ſpar.* / *Barotic vitriol.*

II. The

Species.	Ancient Names.
II. The nitric acid with barytes.	
BARYTIC NITRATE.	*Ponderous nitre.* / *Barotic nitre.*
III. The muriatic acid with barytes.	
BARYTIC MURIATE.	*Ponderous marine ſalt.*
IV. The fluoric acid with barytes.	
BARYTIC FLUATE.	
V. The boracic acid with barytes.	
BARYTIC BORATE.	
VI. The carbonic acid with barytes.	*Aerated ponderous earth.* / *Cretaceous ponderous earth.* / *Barotic chalk.*
BARYTIC CARBONATE.	

X. To theſe neutral ſalts we may join thoſe which owe their nature to the arſenic, the molybdic, the tunſtic, and the ſuccinic acids; calling the firſt, *arſeniates of potaſh, of ſoda, &c.*; the ſecond, *molybdates of potaſh, of ſoda, ammoniacal, calcareous, &c.*; the third, *tunſtates of potaſh, of ſoda, of lime, &c.*; the fourth, *ſuccinates of potaſh, magneſia, aluminous earth, &c.* We ſhall treat of theſe four genera of neutral ſalts in the hiſtory of metallic and bituminous ſubſtances.

XI. Each particular ſalt, whether ſimple or neutral, poſſeſſes certain peculiar characteriſtics, by which it may be diſtinguiſhed from all the reſt. Theſe characteriſtic properties are taſte, form, and alterability—by fire, air, earths, and the various ſaline ſubſtances. In order to learn to diſtinguiſh ſaline bodies readily, we muſt carefully ſtudy all their properties, compare them with

with one another, and mark their differences and contrarieties.

XII. Tho' moſt ſimple ſalts, and ſtill more the neutral ſalts, be almoſt always products of art, yet nature ſometimes affords them at the ſurface, or a very little beneath the ſurface of the earth. Pure barytes or magneſia has not been yet found in nature. Places lying near volcanoes afford lime: the fixed alkalis never appear in a cauſtic ſtate, but always in combination with acids on the ſurface of the earth: the carbonic acid is diffuſed through the atmoſphere, fills ſome ſubterraneous cavities, and exhales from certain waters: the muriatic acid appears to exiſt in a free ſtate on the ſurface of the ſea: the fluoric acid is never found but in combination with lime: the nitric acid is found beſide or among putrifying matters: the ſulphuric acid has been found in cryſtals by M. Baldoſtari in a grotto belonging to the baths of St Philip in Italy, and by M. Dolomieu in a grotto on Mount Etna. M. Vandelli has obſerved, that in the neighbourhood of Sienna and Viterbo, a ſolution of the ſulphuric acid in water filtrates through the rocks, The ſulphureous acid is continually diſengaged in places expoſed to the force of volcanic fires. M. Hoëfer has obſerved the boracic acid in ſolution on the water of ſeveral lakes in Tuſcany.

XIII. Of the forty-two principal * ſpecies of neutral ſalts, of which we have given the hiſtory, only the following

* We ſpeak not here of the modifications of theſe ſalts called *ſulphites, nitrites, oxigenated muriates*, &c. nor of the twenty-eight ſpecies which owe their formation to the metallic and bituminous acids: the number of the neutral ſalts would by that means be much increaſed; and beſides, it does not appear that theſe ſalts exiſt in nature. H.

following perfect neutral ſalts, that is, with a baſe of fixed alkali, are to be found on the ſurface of the earth, in the waters, or in the fluids of organized bodies: Sulphate of potaſh in vegetables; ſulphate of ſoda in water and in ſome plants; nitre in vegetable juices, and in earths impregnated with putrid matters; muriate of potaſh in waters and in marine plants; muriate of ſoda, in earth, water, vegetables growing on the ſea ſhore, and animal humours; carbonate of potaſh in vegetables; carbonate of ſoda in an efflorescence, to the earth, on ſtones, and in animal humours; there is ſome uncertainty in reſpect to borax. Nitrate of ſoda, fluate of potaſh, fluate of ſoda, and borate of potaſh, are always products of art.

XIV. We know of no ammoniacal ſalts exiſting ready formed in nature, but ammoniacal muriate, which is found in places contiguous to volcanoes, and ammoniacal carbonate which is formed in putrid animal matters: ammoniacal ſulphate, ammoniacal nitrate, ammoniacal fluate, and ammoniacal borate, are always formed by the chemiſt in his laboratory.

XV. Calcareous neutral ſalts abound over the ſurface of the globe. We know but of ſix ſpecies of this genus of neutral ſalts; and five of theſe have been found in nature. Calcareous ſulphate or ſelenite exiſts in pretty extenſive ſtrata in hills: carbonate of lime, or calcareous matters, compoſes a conſiderable part of the exterior ſtrata of the globe: calcareous nitrate is always found with common nitre in the beds in which it is produced: calcareous muriate, in like manner, always accompanies muriate of ſoda: calcareous fluate is found in great plenty in mines.

XVI.

XVI. Magneſian ſalts are much leſs copious in nature; none of them but magneſian ſulphate and magneſian muriate, which are found diſſolved in various waters, can be ſaid to exiſt in nature: magneſian nitrate indeed is ſometimes met with, but always in very trifling quantities. Nature has not yet exhibited to our obſervation either magneſian borate, magneſian fluate, or magneſian carbonate. The laſt of theſe, however, appears to exiſt in ſome ſtones.

XVII. Barytic ſulphate is the only one of the ſix barytic neutral ſalts that has been found in any abundance in the mineral kingdom. It is found in the cliffs of hills, and always in the neighbourhood of mines. Neither barytic nitrate, muriate, borate, nor fluate, has as yet been known to exiſt in nature; but pure barytic carbonate was, ſome years ago diſcovered in England, finely cryſtallized, and in large maſſes.

XVIII. Aluminous ſulphate is almoſt the only aluminous ſalt found in nature. It is met with in places adjacent to volcanoes, and among earths that have been expoſed to the action of volcanic fires. It appears alſo in an efflorescence, on decompoſed lava, &c. Pyrites in an efflorescent ſtate likewiſe contains a portion of it. As to aluminous nitrate, muriate, borate, or fluate, theſe are never found among the products of nature. Aluminous earth is often combined with the carbonic acid, and there is ſcarce any earth of the kind from which more or leſs of the carbonic acid may not be obtained by ſtronger acids.

CHAP.

CHAP. XII.

An Examination of ſome general Properties of Salts, particularly Cryſtallization; Fuſibility, tendency to Efflorefce or Deliquiate, Solubility, &c.

IN our hiſtory of ſimple and neutral ſalts, we have conſidered the properties of each ſalt ſeparately: but it may be likewiſe proper to compare them; for, from the compariſon, we may be able to deduce ſome general principles concerning them. Here, then, let us conſider in this point of view the cryſtallization, fuſibility, efflorefcence, deliquefcence, and ſolubility of ſalts.

Cryſtallization, conſidered as a general property of bodies, is a property by which they tend to aſſume a regular form, when placed in circumſtances favourable to that particular diſpoſition of their particles. Almoſt all minerals poſſeſs this property; but it is moſt eminent in ſaline ſubſtances. The circumſtances which are favourable

favourable to the cryſtallization of ſalts, and without which it indeed cannot take place, may be all reduced to the two following: 1. Their particles muſt be divided and ſeparated by a fluid, in order that the correſponding faces of thoſe particles may meet and unite. 2. In order that this union may take place, the fluid which ſeparates the integrant parts of the ſalt muſt be gradually carried off, ſo that it may no longer divide them. From this it may be underſtood, that cryſtallization takes place by virtue of the mutual affinity ſubſiſting between the particles of cryſtallizable bodies, by which they tend to unite into one aggregate maſs. Theſe conſiderations lead us to think that the integrant parts of ſalts have peculiar forms: and that the form of the integrant parts of the ſalt gives to the cryſtal its particular figure. The ſame conſiderations lead us farther to conclude, that the integrant particles of ſalts are ſmall irregular-ſided polyhædrons, ſome of their faces being larger, others ſmaller, and that the largeſt of their faces moſt naturally meet and unite. This being allowed, it will be readily underſtood, that when the fluid which ſeparates theſe particles is carried off, their correſponding faces will reunite; and if the fluid go off ſlowly, ſo as to give the ſaline matters time for a regular arrangement, and to allow them to bring their correſponding faces into contact, the cryſtallization will then be regular. But again, if the fluid be too quickly carried off, the ſaline particles muſt unite haſtily, not by their correſponding faces, but by thoſe which are the moſt contiguous to each other, and the cryſtallization will then be irregular, and the form of the cryſtals not eaſy to determine. Nay, if the ſolu-

tion

tion be very ſuddenly evaporated, the ſalt will appear in a concrete maſs, with nothing of a cryſtalline form.

Theſe are the principles on which we proceed when we attempt to make ſaline matters aſſume the cryſtalline form. All ſalts are ſuſceptible of cryſtallization; but they do not all cryſtallize with equal readineſs. Some ſalts cryſtallize ſo readily, that we can make them aſſume the cryſtalline form at pleaſure. Others again require more care and many precautions. And, laſtly, there are ſeveral which we have not yet been able to obtain in cryſtals. In order to ſucceed in attempts to cryſtallize ſalts, it is requiſite for us to be well acquainted with the circumſtances moſt favourable to the cryſtallization of each. In ſuch operations it is a neceſſary condition that the ſaline ſubſtances be firſt diſſolved in water: but ſome ſalts are ſo difficult of ſolution, that it is almoſt impoſſible to make their integrant particles unite regularly. Such are calcareous ſulphate, calcareous carbonate, calcareous fluate, and barytic ſulphate. In nature, theſe neutral ſalts are daily met with in very regular cryſtals; but art cannot imitate them but by a very tedious proceſs; nay, a number of eminent chemiſts deny the poſſibility of any ſuch proceſs. I take my account of it from M. Achard, who aſſerts, that by this proceſs he obtained calcareous carbonate in cryſtals. This ingenious proceſs conſiſts in making water that has long ſtood over thoſe ſalts which diſſolve with ſo much difficulty, to run along a very narrow canal, and there evaporate very ſlowly. Again, there are other ſaline matters ſo ſoluble, and ſo much diſpoſed to remain in union with water,

water, that it is exceedingly difficult to ſeparate them from it, and make them cryſtallize regularly. This is the character of all deliquiating ſalts, ſuch as calcareous and magneſian nitrate and muriate.

Each particular ſalt, no doubt, muſt cryſtallize in a way peculiar to itſelf; or, what is the ſame thing, the moſt minute particles of every ſaline ſubſtance muſt have a determinate form, by which they are diſtinguiſhed from the integrant particles of every other ſaline matter. This is doubtleſs the cauſe of that amazing variety of forms which cryſtalline bodies exhibit. The ſimple ſalts, from the ſalino-terrene ſubſtances to the ſtronger acids, have ſcarce ever a diſtinct, determinate form: and there are but a few circumſtances which can cauſe them to cryſtallize without totally deſtroying their ſaline properties; which actually happens to the oxigenated muriatic and the concrete ſulphuric acids. The cauſtic alkalis, however, cryſtallize in plates, according to M Berthollet, and the acid of borax is well known to exhibit the ſame figure. But, excepting theſe two, none of the ſimple ſalts can be made to aſſume any regular form, either becauſe their nature does not admit of it, or becauſe the means which we employ are inadequate to the purpoſe. But all the neutral or middle ſalts naturally affect a regular form, and we can even cauſe moſt of them to aſſume or reſign it at pleaſure. When we conſider this property by which neutral ſalts are ſo eminently diſtinguiſhed from the ſimple, we are at a loſs to determine whether it be owing to the acids or to the alkaline baſes by which they are neutralized: but it cannot be excluſively aſcribed to either the one or the other; for the ſame acid

cid in combination with various baſes often forms cryſtals of a great variety of figures; while again the ſame baſe in combination with various acids often exhibits a like diverſity of forms. The cryſtallization of neutral ſalts is therefore to be aſcribed to a total change of the properties of both the acid and the baſe.

There are three ways of making ſalts cryſtallize, commonly practiſed in the laboratory. 1. The firſt is evaporation. This proceſs conſiſts in heating a ſaline ſolution till the water by which its particles are kept ſeparate be reduced to vapour. The ſlower the evaporation, ſo much the more regular will the cryſtallization of the ſalts be. The proceſs for cryſtallizing ſulphate of potaſh, muriate of potaſh, muriate of ſoda, calcareous ſulphate, and magneſian carbonate, is conducted on this principle. When a ſolution of any of theſe ſalts is evaporated by a boiling heat, the form in which the ſalt is obtained, is far from being regular: but if placed on a ſand bath, of the heat of nearly 133° 15′ F. the ſame ſolution conſtantly gives either ſooner or later very beautiful regular cryſtals: And there is ſcarce any ſalt which may not be made to aſſume a regular form by this proceſs judiciouſly conducted. 2. Cooling is ſucceſsfully applied to cryſtallize ſuch ſalts as are more ſoluble in warm than in cold water. It is eaſy to ſee, that a ſalt of this nature will cryſtallize as ſoon as the water in which it is diſſolved becomes incapable of maintaining it fully in ſolution, in conſequence of its temperature being diminiſhed. That portion of the ſalt which owed its ſolution to the temperature of the fluid, is gradually ſeparated as the liquor cools; and when the water becomes quite cold,

no

no more of the ſalt remains diſſolved but what is ſoluble in cold water. In this proceſs, as in the former, when the ſolution is cooled the moſt ſlowly, and the ſaline particles are ſuffered to unite their correſponding faces, the cryſtals are then moſt regular: And therefore ſolutions of ſalts ſhould be for ſome time expoſed to a certain degree of heat; which ſhould be afterwards diminiſhed gradually till it be reduced to the loweſt degree requiſite. It is to be obſerved, that all ſalts ſuſceptible of cryſtallization by this proceſs, are in general much more ſoluble than thoſe which are cryſtallized by the firſt proceſs; as they are at firſt diſſolved in boiling water, if the ſolution be ſuddenly cooled, the ſalt falls to the bottom in a ſhapeleſs maſs; but if put on a ſand-bath, and ſlowly cooled, the cryſtallization is always regular. By this means ſulphate of ſoda, nitre, carbonate of potaſh, carbonate of ſoda, ammoniacal muriate, &c. are obtained in fine cryſtals.

3. The third method of cryſtallizing ſalts is ſpontaneous evaporation. This is obtained by expoſing a very pure ſolution of the ſalt which we wiſh to cryſtallize, to the temperature of the atmoſphere in a glaſs or ſtone veſſel covered with gauze; which prevents any duſt from falling into the liquor without retarding the evaporation. The veſſel with the ſolution is to be ſet aſide in an apartment not otherwiſe occupied, and there ſuffered to remain till cryſtals appear; four or five months, or perhaps a longer ſpace, will ſometimes elapſe before that happen. The largeſt and moſt regular cryſtals are uſually obtained by this proceſs. Did time allow, it might be applied to all ſalts; for by means of it they are obtained in the higheſt purity. It is abſolutely neceſſary

ceſſary for the cryſtallization of nitrate of ſoda, muriate of ſoda, borax, aluminous ſulphate, magneſian ſulphate, ammoniacal ſulphate, ammoniacal nitrate, &c.

On ſome occaſions two or more of theſe proceſſes are employed together; as for inſtance, in the cryſtallization of ſalts which have a ſtrong tendency to deliquiate, ſuch as calcareous nitrate, calcareous muriate, magneſian nitrate, and magneſian muriate. Solutions of theſe ſalts are firſt powerfully evaporated, and then expoſed to an extreme cold. But this method never gives regular cryſtals; and ſometimes we obtain by it nothing but ſhapeleſs concrete maſſes. The reaſon why we are able to cryſtallize ſo few of the neutral ſalts, is our not knowing exactly in what ſtate of concentration the ſolutions of various ſalts muſt be, in order that they may afford cryſtals. Though this knowledge might eaſily be obtained, as nothing but time and patience are requiſite for the purpoſe, yet chemiſts have not made it ſufficiently the object of their attention. The ſpecific gravities of ſaline ſolutions muſt be obſerved, in order that we may come to know the degree of concentration requiſite for the cryſtallization of each. In ſome operations on ſalts in the great way, an areometer, or inſtrument for meaſuring the ſpecific gravities of liquids, has been happily employed to determine the point at which the ſolution might be expected to cryſtallize.

Beſide theſe methods of effecting the cryſtallization of ſalts, there are ſeveral circumſtances favourable to that operation, the influence of which it will be proper to eſtimate. Gentle agitation ſometimes contributes to

effect a cryſtallization, which might otherwiſe not ſucceed. When veſſels containing ſaline ſolutions are ſhaken or removed from one place to another, we ſometimes ſee cryſtals inſtantly formed, though the ſaline matter was immediately before entirely in ſolution. The contact of the air is indiſpenſibly neceſſary to the formation of cryſtals. It often happens that a ſaline ſolution, though evaporated to the proper point, gives no cryſtals, on account of its being confined in a cloſe flaſk; whereas, if it were expoſed to the air in an open veſſel, it would cryſtallize with great rapidity. Roucelle the elder made this obſervation in a very accurate manner. The form of the veſſels, too, and extraneous matters happening to be intermixed with the ſolution, have great influence on the cryſtallization of a ſalt. The firſt of theſe circumſtances modifies the figure of the cryſtals, and diverſifies them in an amazing manner. Thus, threads or ſmall ſticks are put into veſſels containing ſaline ſolutions, to make them cryſtallize with greater regularity. The cryſtals are depoſited on the threads, their baſes are then very narrow, and they therefore aſſume a more regular form than when they fall upon the ſides of earthen pots, or any of the other veſſels commonly made uſe of in this proceſs; which being oblique, irregular, and unequal, mutilate and deſtroy the regularity of cryſtals. Extraneous bodies immerſed into ſolutions of ſalts are often ſerviceable; they cauſe the cryſtallization to take place ſooner than it would otherwiſe have done. A bit of wood or a ſtone thrown into a ſalt ſpring, becomes a baſe on which the water depoſites cryſtals of muriate of ſoda. Some chemiſts, in conſequence of obſerving this phænomenon, have

have been induced to propoſe the immerſion of ſaline cryſtals into ſaline ſolutions, which do not cryſtallize readily. Several have aſſerted this circumſtance to be highly favourable to the cryſtallization of ſuch ſalts as cannot without great difficulty be obtained under a regular form. Theſe are the chief circumſtances which influence cryſtallization. Future obſervation, no doubt, may make chemiſts acquainted with many more.

A ſalt cannot be ſeparated from the water by which it was diſſolved, ſo as to aſſume a regular form, unleſs it retain ſome part of the fluid. The reader may convince himſelf of this fact by taking a portion of ſome ſalt reduced to a powder by heat, ſuch as aluminous ſulphate or borate of ſoda calcined, or dried ſulphate of ſoda; diſſolving it in water, and cauſing it to cryſtallize: and it will be found to have gained an augmentation, ſometimes even of an half more, in conſequence of being cryſtallized; that is, an ounce of ſalt will increaſe to two ounces by cryſtallization. Chemiſts have inferred from this fact, that a ſalt when formed into regular cryſtals, contains more water than when deprived of its cryſtalline form by the action of fire or air. This water, which though not one of its principles as a ſaline ſubſtance, is yet eſſentially neceſſary to its conformation into cryſtals, they call *the water of cryſtallization*; becauſe it is in fact an element of ſaline cryſtals. When deprived of this water, cryſtals loſe their tranſparency and regularity of form. Salts contain, ſome a greater, ſome a leſs quantity of this water of cryſtallization. Some ſalts, ſuch as ſulphate of ſoda, carbonate of ſoda, and aluminous ſulphate, contain a quantity of water equal to half their weight; others, ſuch

as nitre, muriate of ſoda, &c. poſſeſs but a ſmall portion of water. The various proportions in which the water of cryſtallization ſubſiſts in the various ſalts, have not yet been accurately determined. Salts may loſe this water without ſuffering any alteration of their intimate nature; and the water itſelf is perfectly pure like diſtilled water.

As from what we have ſaid concerning the cryſtallization of ſalts, it appears that ſaline ſubſtances are not all cryſtallized by the ſame proceſs, but obey different laws in their formation into cryſtals; it is plain that we may take advantage of this circumſtance, when we attempt to ſeparate different ſalts from one another. Thus a ſalt which cryſtallizes by cooling may be obtained entirely ſeparate from another which cryſtallizes only by continued evaporation; in this manner are the muriate of ſoda and the ſulphate of ſoda contained in the ſpring-waters of Lorraine, ſeparated from each other. It often happens, however, that two ſalts, when diſſolved in the ſame water, are ſo blended together, that repeated ſolutions and cryſtallizations are neceſſary to effect an entire ſeparation between them. This obſervation holds ſtill more ſtrongly in regard to thoſe ſalts which are ſubject to the ſame laws of cryſtallization. Theſe are much more difficult to ſeparate from each other, eſpecially if there be a number of them together. For inſtance, if the ſame water ſhould happen to contain four different ſalts, all equally diſpoſed to cryſtallize by either evaporation or cooling, it would not be poſſible to ſeparate them by one or two ſucceſſive proceſſes of cryſtallization: but the operation would require to be many times repeated, in order that the

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nice variations which diverſify the characters of thoſe ſalts might be brought to diſplay themſelves: For it is to be remarked, that though two or more ſalts appear ſubject to the ſame laws of cryſtallization; yet when minutely obſerved, the cryſtallization of the one will be always found diſtinguiſhed from that of the other by ſome ſlight differences. Were this not the caſe, they would always cryſtallize together, nor would it be at any time poſſible to obtain them ſeparate; but this ſcarce ever happens, even in regard to thoſe ſalts which cryſtallize in the moſt uniform manner. There are, however, ſome exceptions from this rule: ſome ſalts have a peculiar tendency to mutual adheſion, or an uncommon affinity with each other. Of this kind are all neutral ſalts which owe their formation to the ſame acid, and cryſtallize by the ſame proceſs; ſuch as the magneſian and ammoniacal ſulphates. But theſe ſingular phænomena of neutral ſalts have not been as yet obſerved with ſufficient attention; and there is here ſtill farther ſcope for the reſearches of the chemiſt.

Laſtly, To conclude this compendious hiſtory of the cryſtallization of ſalts, let us take notice that there is another mode of obtaining them in cryſtals. Saline ſolutions may be precipitated by ſome ſubſtance that has a greater affinity than they with the water. Spirit of wine produces this effect on moſt of the neutral ſalts; on all of them indeed but ſuch as are ſoluble in that menſtruum. The ſame phænomenon takes place when ſalts, differing conſiderably from each other in point of ſolubility, happen to be mixed together; even when ſeveral different ſaline ſolutions are mixed, though the

ſalts differ not greatly as to ſolubility. Thus ſulphate of magneſia diſſolved in water precipitates a ſolution of ammoniacal ſulphate. But what paſſes on this occaſion has not yet been obſerved with ſufficient attention to enable me to give a particular account of this ſingular phænomenon.

Fuſion by heat was treated of when we gave the particular hiſtory of each ſaline ſubſtance by itſelf; but we may here compare the different kinds of fuſion of which ſalts are ſuſceptible. Salts are liable to two kinds of fuſion; the one, which is peculiar to ſaline matters, is owing to water, and is called *aqueous fuſion*: the other, which ariſes from a different cauſe, is known by the name of *igneous fuſion*. Aqueous fuſion depends entirely on the water of cryſtallization; which as it exiſts in many ſalts in a large proportion, amounting often to half the weight of the cryſtal, is capable of diſſolving ſuch ſalts when heated to the temperature of 167°. The cryſtalline form then diſappears, the ſalt is diſſolved, and the fuſion which takes place is in fact a real ſolution. This obſervation is ſo juſt, that when a ſalt of this nature, ſuch as ſulphate of ſoda, borate of ſoda, or aluminous ſulphate, is kept for ſome time in this ſtate of fuſion, the water which with the help of heat diſſolved it, is gradually evaporated, and the ſalt is left dry, and no longer appears in a ſtate of fuſion. This apparent or aqueous fuſion has no relation to true igneous fuſion; for all ſalts that have been dried after being once liqueſied by their water of cryſtallization are ſuſceptible of the latter. Thus muriate of ſoda, and borate of ſoda, are melted by a ſtrong heat, after ſuffering aqueous fuſion and being dried up by a moderate

moderate heat. All falts have not an equal tendency to true igneous fufion: There are fome, fuch as nitrate and muriate of foda, which melt as foon as they begin to become red-hot: others again, fuch as fulphate of potaſh and fulphate of foda, require a much more intenſe heat to melt them. Laſtly, Such is the fufibility of fome falts, that they are capable of communicating this property to other bodies fcarce fufible by themſelves. Thus the fixed alkalis communicate their fufibility to quartz, ſand, and all other ſiliceous earths, which are otherwiſe abſolutely infufible. This property has acquired to theſe falts the title of *fluxes*, becauſe they are employed to promote the fufion and vitrification of earthy and metallic ſubſtances. We have already remarked in another place, that the laſt degree of fufibility is volatilization. And we would here obſerve, that all ſaline matters are more or leſs volatile; not one of them but may be volatilized by an extreme heat. Thus ſulphate of potaſh and muriate of ſoda, when heated to the higheſt temperature of which they are capable, are ſublimated into vapour.

Cryſtalized falts do not all ſuffer the ſame alteration from the action of air. Some of them ſuffer no diſcernible alteration when expoſed to it, but many loſe ſooner or later their tranſparency and form; and of theſe ſome melt down gradually, acquiring at the ſame time additional weight, while others, as they become pulverulent, ſuffer a diminution of weight. The firſt of theſe alterations is called *deliquefcence*, the other *efflorefcence*.

That phœnomenon which is known by the name of *deliquefcence*, is ſo called becauſe the ſaline matter

which exhibits it, then becomes liquid; and a ſalt is ſaid to fall into a *deliquium*, when it melts in this manner on coming into contact with air. The word *defaillance* was formerly uſed by *French* chemiſts as ſynonimous with *deliqueſcence*, but it is now become antiquated, and no longer appears in the writings of chemiſts. The occaſion of this alteration is, that the ſalts attract the moiſture of the atmoſphere; which, in my opinion, is to be conſidered as a real elective attraction between the water and the ſalt, which acts with ſuch ſuperior force as to ſeparate the water from the air of the atmoſphere. There are alſo differences among ſalts, in regard to their tendency to deliquiate, both in reſpect to the rapidity with which this change takes place, and the point of ſaturation at which the phænomenon of deliqueſcence ceaſes. The fixed alkalis, ammoniac gas, the muriatic acid gas, and the concentrated ſulphuric acid, abſtract the water from the atmoſphere, dry up the air, if we may be allowed to uſe the expreſſion, with a very conſiderable force, and abſorb a quanity of the fluid more than equal to their original weight. Dry potaſh particularly diſplays this phænomenon in a very eminent manner; ſo likewiſe does the ſulphuric acid when concreted by cold. Theſe two ſalts firſt become ſoft, and afterwards aſſume a thick liquid conſiſtency, reſembling that of ſome oils; which has cauſed the firſt to receive the name of *oil of tartar*, and the ſecond to be called *oil of vitriol*. But theſe names are improper, and more likely to miſlead than to enlighten a perſon entering upon the ſtudy of chemiſtry. There are other ſalts which have a ſtrong tendency to deliquiate, but do not attract moiſture ſo copiouſly

copiouſly or with ſo much avidity as thoſe above-mentioned. Such are calcareous nitrate and calcareous muriate, magneſian nitrate and magneſian muriate. Laſtly, There are ſome ſalts which, when expoſed to the atmoſphere, only become a little wet, without waſting entirely down, ſuch as nitrate of ſoda, muriate of potaſh, ammoniacal ſulphate, &c.

The phænomenon of efflorеſcence has been ſo named, becauſe the ſalts ſuſceptible of it appear covered over with ſmall white threads, reſembling thoſe ſublimated matters which are known in chemiſtry by the name of *flowers*. This property is the direct contrary of deliqueſcence. In the inſtance of deliqueſcence, the ſaline cryſtals decompoſe moiſt air; becauſe the elective attraction ſubſiſting between the ſalt and the water is ſtronger than that between the water and the air. In efflorеſcence, again, the atmoſphere decompoſes the ſaline cryſtals, as having a greater affinity with water than the ſalts. In efflorеſcence, therefore, the water of cryſtallization is abſtracted from the ſalts; and this is the reaſon why ſalts, when they efflorеſce, loſe their form, their tranſparency, and a part of their bulk. It is here of importance to obſerve, that all efflorеſcent ſaline cryſtals ſuffer from heat It is a kind of cold calcination which ſlowly decompoſes cryſtallized ſalts, by ſeparating from them the water to which they owe their cryſtalline form, and all their other properties as ſaline cryſtals. When a ſalt therefore efflorеſces entirely, it ſuffers exactly the ſame loſs of weight as when it is dried by the action of fire. We may farther remark, that thoſe ſalts whoſe cryſtals efflorеſce, belong to the

claſs

claſs which is the moſt ſoluble, and cryſtallizes by cooling.

Efflorescence, like deliquescence, is not exactly the ſame in all the neutral ſalts ſuſceptible of it. Some, ſuch as ſulphate and carbonate of ſoda, efflorese readily and entirely, ſo that after exhibiting this phænomenon, they are found to be wholly reduced to a fine white duſt. As they appear to have loſt, in conſequence of this decompoſition, half their weight, it may be inferred, that their efflorescing ſo completely is owing to their containing ſo much water of cryſtalliization. And it is a fact, that ſalts which are but little ſuſceptible of efflorescence, ſuch as aluminous and magneſian borate and ſulphate, contain leſs water in their cryſtals. If efflorescence depend on air's having a greater affinity with water than the efflorescent ſalts have, it muſt follow, that when the atmoſphere is very dry, this phænomenon will take place more readily and in a more remarkable manner, while air loaded with moiſture will not act in the ſame manner on efflorescent ſalts, but will leave them uninjured. To confirm this aſſertion; if a ſmall portion of water be ſprinkled on ſaline cryſtals ſuſceptible of efflorescence, the ſurrounding atmoſphere being ſaturated by the abſorption of this water, does not affect that which enters into the conformation of the cryſtals, but leaves them unaltered. But if the cryſtals be not again wetted after the atmoſphere has once abſorbed the water which has defended them againſt its influence, the air then makes an impreſſion on the ſaline ſubſtance, and deſtroys its cryſtallization. In apothecaries ſhops, this phænomenon is daily obſerved; they find it neceſſary to keep ſulphate of ſoda, or

Glauber

Glauber ſalt, conſtantly wet with a little water, in order to preſerve it in cryſtals.

The ſolution of ſalts in water is one of thoſe phænomena which are the moſt worthy of the chemiſt's attention. Some perſons obſerving that it takes place without any ſenſible motion, and without the effervescence which always accompanies the ſolution of metals in acids, have propoſed to call the one *ſolution*, and the other, which is attended with effervescence, *diſſolution*. But as theſe two expreſſions have preciſely the ſame meaning, and the reciprocal action of acids and metals is a phænomenon very different from the ſolution of ſalts, we do not think that this diſtinction can be attended with any advantage. The ſolution of ſalts has been conſidered by ſome philoſophical chemiſts as being ſimply a mechanical diviſion of the ſaline particles: but the two bodies penetrate each other in a very intimate manner; their temperature too is inſtantly changed, and a real combination appears to take place between the ſalts and the water, which cannot be explained by referring it to the mere ſeparating of the ſaline particles. This appears, not only from the change of temperature which takes place on theſe occaſions, but likewiſe from the poſſibility of ſeparating one ſalt from water by the application of another which has a greater affinity with the fluid: thus potaſh precipitates ſulphate of potaſh, and calcareous carbonate from water in which either of theſe ſalts is diſſolved. All the precipitations of ſalts are far from being well known; and therefore a ſeries of experiments inveſtigating them would be of great uſe to chemiſtry. The reader might obſerve in the particular

lar hiſtory of every ſaline ſubſtance, that they poſſeſs different degrees of ſolubility; ſome having ſuch a tendency to combine with water, that they remain always fluid, as for inſtance, the ſulphuric and the nitric acids; while others, ſuch as barytic ſulphate, are almoſt perfectly inſoluble. Several chemiſts have already attempted to exhibit in tables the various degrees of ſolubility of the different ſalts. But ſuch tables muſt always be incomplete till ſuch time as the ſolubilities of the different ſalts be very accurately determined by a numerous train of experiments. We may here again take notice, that all ſimple ſalts, whether alkaline or acid, conſtantly produce heat when diſſolved in water; whereas cold is conſtantly excited during the ſolution of neutral ſalts. The changes of temperature which the different ſimple and neutral ſalts ſuffer on being diſſolved in water are not yet fully known; but chemiſts are now beginning to pay more attention to this object than they formerly did. Some uſeful diſcoveries will ſurely be the reſult of ſuch a train of reſearches; it has already led to the knowledge of ſome truths, which were not even gueſſed at before. For inſtance, when we obſerve that the neutral ſalts which produce moſt cold when diſſolved, ſuch as ſulphate of ſoda, ammoniacal nitrate, and ammoniacal muriate, are much more ſoluble in warm than in cold water; is it not reaſonable to infer, that this phænomenon is owing to their finding in warm water a greater quantity of heat than it is requiſite for them to abſorb, in order that they may be liquefied? And in fact they are eaſily deprived of this exceſs of heat by the action of air; ſo that part of the ſalt is precipitated in cryſtals as the liquor cools.

CHAP

CHAP. XIII.

Of the Elective Attractions which take place between different Saline Matters.

THE numerous diſcoveries made by chemiſts concerning the nature of ſaline matters ſince the middle of the preſent century, have eſtabliſhed it as a certain fact, that there ſubſiſt between theſe matters different degrees of affinity or elective attraction. Geoffroy was the firſt who compared them together; but late reſearches have ſhown, that his table was very erroneous. Bergman has corrected his errors, and has made us acquainted with many more of the elective attractions ſubſiſting among ſalts: Yet, on conſulting the articles of the celebrated Swediſh chemiſt's table, which relate to the elective attractions of ſaline ſubſtances, we find ſeveral which are not founded on a ſufficient

ſufficient number of experiments, and the uncertainty of which he himſelf acknowledges. Inſtead of extending the theory of elective attractions to ſo great a number of ſalts as Bergman has, we muſt confine it in the preſent ſtate of chemiſtry to the examination of the affinities which take place between thoſe ſaline matters whoſe nature and properties are beſt known.

Of the ſix ſpecies of acids which we have examined, the ſulphuric acid appears to be the ſtrongeſt, or to have the moſt remarkable elective attractions for the different baſes; that is to ſay, it ſeparates moſt of the alkaline or ſalino-terrene baſes from the other acids; it decompoſes nitrates, muriates, fluates, borates, and carbonates, by extricating their acids.

The nitric acid generally holds the ſecond rank: it yields the alkaline baſes to the ſulphuric acid, but attracts them from the four following acids.

In order to make the reader better acquainted with the different affinities which take place between the mineral acids and the ſaline baſes of the ſame kingdom, we ſhall lay them down in the order in which Bergman arranges them in his Table of Affinities. Let us conſider, 1. Each acid as related to the different ſaline baſes with which it may be combined: 2. Each of the alkaline matters in relation to the acids which ſaturate them, and to the degree of force with which they combine with theſe ſalts.

I. The elective attractions of the ſulphuric acid for the different baſes, are arranged by Bergman in the following

following order, beginning with that baſe with which it has the ſtrongeſt adheſion*.

The SULPHURIC ACID.

Barytes.
Potaſh.
Soda.
Lime.
Ammoniac.
Magneſia.
Aluminous earth.

As the nitric and the muriatic acids attract the alkaline baſes in the ſame order, we may give them immediately after the ſulphuric acid.

The NITRIC ACID.

Barytes.
Potaſh.
Soda.
Lime.
Ammoniac.
Magneſia.
Alumine.

The

* We have already given the order of the affinities of the acids with the baſes in the hiſtory of each of thoſe ſubſtances; but we think proper to exhibit them here in columns, as is done in tables of affinities, in order that they may appear under one point of view, and be compared together. F.

The MURIATIC ACID.

Barytes.
Potaſh.
Soda.
Lime.
Ammoniac
Magneſia.
Alumines.

Barytes has therefore a greater affinity than any of the other baſes with the ſulphuric, the nitric, and the muriatic acids, and decompoſes all neutral ſalts that are formed by the union of theſe acids with the alkaline matters. Bergman places magneſia before ammoniac, becauſe, he tells us, that ſalino-terrene ſubſtance decompoſes ammoniacal ſalts. We may remark, that ammoniac decompoſes magneſian ſalts more completely. Magneſia indeed is never entirely precipitated by this alkali. Mixed or triple ſalts are found to remain in the liquor, which are formed by the union of the magneſian with the ammoniacal ſalts. We apprehend, notwithſtanding our reſpect for the authority of Bergman, that there is a greater affinity between ammoniac and the acids, than between the acids and magneſia: for though magneſia diſengages a little ammoniac from ammoniacal ſalts in the humid way, yet it does not decompoſe theſe ſalts by diſtillation. We have therefore placed ammoniac before magneſia; and we think Bergman's table needs this correction.

II. The

II. The elective attractions of the fluoric acid for the alkaline baſes are very different from thoſe of the three foregoing acids. The alkalis yield this acid to lime and the two other ſalino-terrene ſubſtances. A ſolution of barytic fluate in hot water is precipitated by lime-water; and the precipitation is immediately followed by the formation of calcareous fluate. The caſe is the ſame with the other fluoric neutral ſalts: lime deprives them of the acid,—as Bergman ſhows in his eighth table, which is thus arranged.

THE FLUORIC ACID.

Lime.
Barytes.
Magneſia.
Potaſh.
Soda.
Ammoniac.
Alumine.

The ſame phænomena take place, in the dry way; for calcareous fluate is decompoſed by carbonate of potaſh and of ſoda, but not by the pure and cauſtic fixed alkalis.

III. Bergman exhibits in his tenth table the affinities of the boracic acid in the ſame order with thoſe of the fluoric; becauſe, when borax is heated with quicklime in water, the quicklime fixing the acid forms with it calcareous borate which is ſcarce ſoluble, and leaves the ſoda pure. As to the other baſes, he gives

the order of their affinities with this acid only by analogy; and he acknowledges his diſpoſition of them to be no more than a probable conjecture. *Quod idem accidat*, ſays he, *cum alkali vegetabili, acido boracis ſaturato, hactenus tantum probabilis eſt conjectura, aquæ ac terræ ponderoſæ et magneſiæ poſitura.*

The Acid of Borax.

Lime.
Barytes.
Magneſia.
Potaſh.
Soda.
Ammoniac.
Alumine.

IV. The elective attractions of the carbonic acid are ſomewhat different from thoſe which have been laid down as belonging to the other acids. This acid adheres more ſtrongly to barytes, and next after barytes to lime, than to any other ſubſtance. Ammoniac ſeparates it from magneſia, as Bergman has ſhown by very accurate experiments. Here, therefore we cannot make the obſervation which we have made with reſpect to the other acids; and we ſhall give part of the twenty-fifth column of that celebrated chemiſt's table of affinities, which exhibits the attractions of the carbonic acid for the ſeveral ſaline baſes.

The

THE CARBONIC ACID.

Barytes.
Lime.
Potaſh.
Soda.
Ammoniac.
Magneſia.
Alumine.

V. The ſeven earthy or alkaline baſes whoſe combinations with the mineral acids we have examined, differ from one another in their elective attractions for the ſame acids. Five of them, namely the two fixed alkalis, ammoniac, lime, and aluminous earth, agree in the order of their affinities. All the five adhere to the acids in the following order; the ſulphuric acid, the nitric acid, the muriatic acid, the fluoric acid, the boracic acid, and the carbonic acid. But barytes and magneſia differ from the five firſt baſes in their affinities with the mineral acids, and agree with each other.

Bergman diſpoſes the elective attractions of barytes and magneſia, in reſpect to the mineral acids, in the following order.

BARYTES AND MAGNESIA.

The ſulphuric acid.
The fluoric acid.
The nitric acid.

The muriatic acid.
The boracic acid.
The carbonic acid.

The only difference between theſe affinities and thoſe of the five foregoing baſes, is, that the fluoric acid here ſtands before the nitric and the muriatic acids; which ſhows that barytic and magneſian nitrates and muriates are decompoſed by the fluoric acid;—whereas barytic and magneſian fluates are not liable to be deprived of their baſes by the nitric and the muriatic acids.

VI. The elective attractions of which we have given an account, ſhow the order of the ſimple decompoſitions which are effected when three ſaline matters are mixed together. But it is not enough to know theſe affinities or ſimple elective attractions; we muſt alſo attend to thoſe which take place among four ſaline ſubſtances.

It is to be remembered, that by double affinity, we underſtand a double affinity in virtue of which a compound of two bodies which could not have been deſtroyed by either a third or a fourth body ſeparately, is yet decompoſed with the greateſt facility when theſe two laſt bodies are combined together. This double elective attraction often takes place among neutral ſalts. Thus, calcareous ſulphate, nitrate, or muriate, cannot be decompoſed by either ammoniac or the carbonic acid taken ſeparately: becauſe the firſt of theſe bodies has leſs affinity than lime with the ſulphuric, the nitric, and the muriatic acids; and the ſecond again has

leſs

leſs affinity with lime than even theſe acids: But when theſe calcareous ſalts are brought into contact with a compound of ammoniac and the carbonic acid, that compound deſtroys the adheſion of their principles. In that chapter in which I treated of affinities in general, I have ſhown how this phænomenon may be explained, by numbering the degrees of the attractive force exerted on the occaſion. I have attempted to apply the idea to ſaline matters; but as we are ſtill but imperfectly acquainted with the nature and the combinations of the fluoric and the boracic acids, I have applied it only to the ſulphuric, the nitric, the muriatic, and the carbonic acids, conſidered in relation to the mineral ſaline baſes, and the degrees of adheſion which they appear to have with theſe baſes. The numbers which I have employed to expreſs the different degrees of adheſion, are founded on the reſult of ſimple decompoſitions. Perhaps they do not expreſs accurately the force of affinity; but the deſign of employing them is only to ſhow the cauſe of double affinities.

I will firſt give a table, expreſſing in numbers the affinities of the four acids with fix baſes; not including barytes, becauſe we are not yet well enough acquainted with the various ſaline combinations into which that ſubſtance enters. Afterwards, I ſhall lay down in particular tables the double affinities known to ſubſiſt among the neutral ſalts; adopting Bergman's mode of arrangement, which I have already deſcribed under the article of affinities in general. I may here obſerve, that in this ingenious arrangement, to which the only addition that I have made is expreſſing the

affinities in numbers, the ſum of the two vertical numbers which indicate the divellent attractions, is to be conſidered as ſtanding in oppoſition to the ſum of the horizontal numbers which indicate the quieſcent attractions; which oppoſition of attractions is the cauſe of the decompoſition effected by double affinity.

TABLE *of the Degrees of Attraction between four Acids and ſix Baſes, expreſſed in Numbers.*

COLUMN FIRST.

The ſulphuric acid combines with	Potaſh, with an affinity equal to	8
	Soda	7
	Lime	6
	Ammoniac	4
	Magneſia	3½
	Aluminous earth	2

COLUMN SECOND.

The nitric acid combines with	Potaſh, with an affinity equal to	7
	Soda	6
	Lime	4
	Ammoniac	3
	Magneſia	2
	Aluminous earth	1

COLUMN THIRD.

The muriatic acid combines with	Potaſh, with an affinity equal to	6
	Soda	5
	Lime	3
	Ammoniac	2
	Magneſia	1
	Aluminous earth	½

COLUMN

COLUMN FOURTH.

The carbonic acid combines with

Lime, with an affinity equal to	3
Potaſh	2
Soda	1
Ammoniac	$\frac{1}{2}$
Magneſia	$\frac{1}{3}$
Aluminous earth	$\frac{1}{4}$

A TABLE *exhibiting ten Kinds of double Affinity which take place among the ſeveral Neutral Salts, in Numbers taken from the preceding Table.*

I.

Nitre.

Potaſh. 7 The nitric acid.

Sulphate of potaſh. 8 quieſcent affinities 4 { 12* } Calcareous nitrate.

divellent affinities

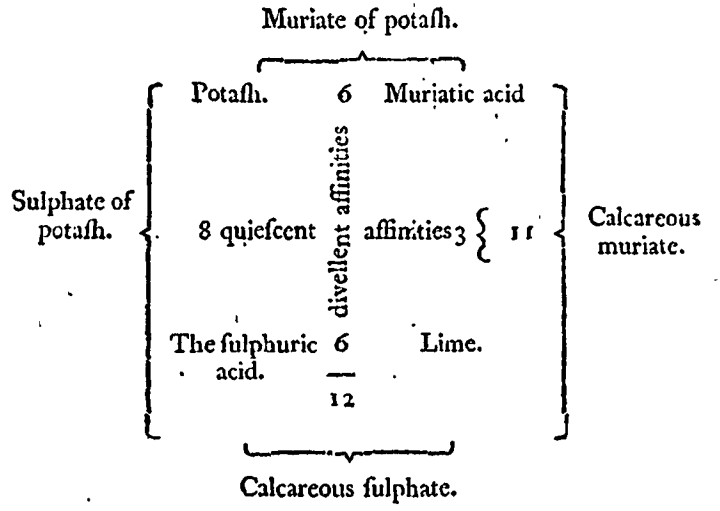
The ſulphuric acid. 6 Lime.

13

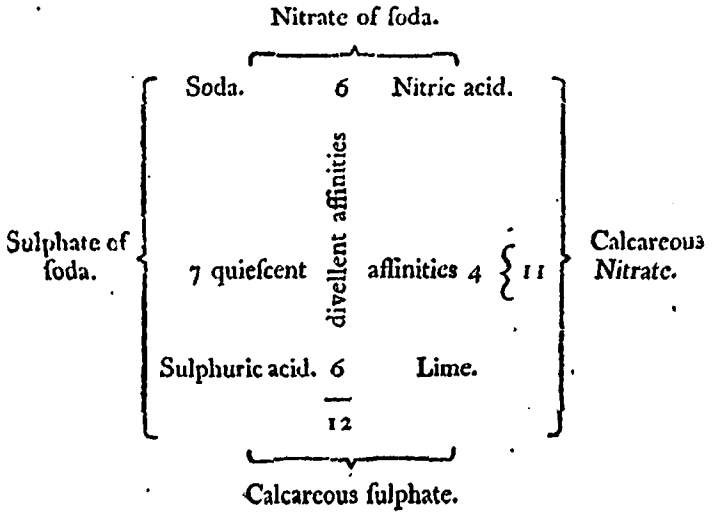
Calcareous ſulphate.

* The number placed on the right ſide between the ſmall and the large bracket, is the ſum of the two horizontal or *quieſcent* affinities; and the decompoſition cannot take place unleſs this ſum be leſs than that of the two *divellent* affinities. F.

II.

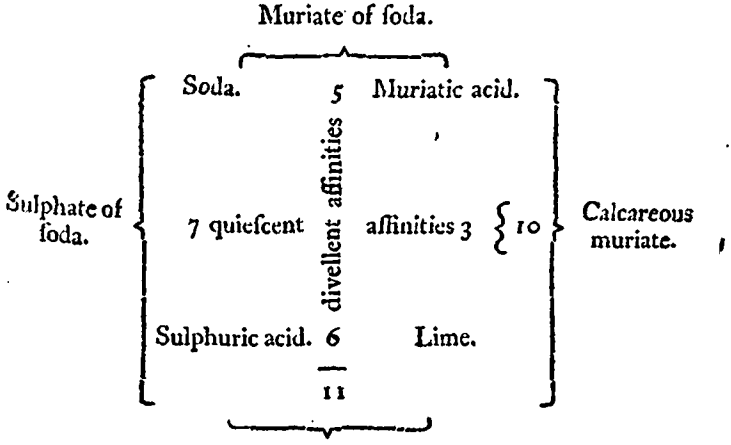

Muriate of potaſh.
Potaſh. 6 Muriatic acid
Sulphate of potaſh.
8 quieſcent
divellent affinities
affinities 3
11
Calcareous muriate.
The ſulphuric acid. 6 Lime.
12
Calcareous ſulphate.

III.

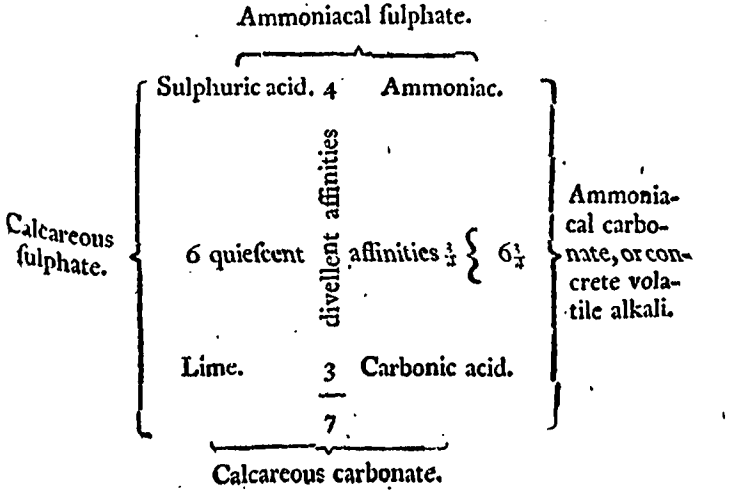

Nitrate of ſoda.
Soda. 6 Nitric acid.
Sulphate of ſoda.
7 quieſcent
divellent affinities
affinities 4
11
Calcareous Nitrate.
Sulphuric acid. 6 Lime.
12
Calcareous ſulphate.

IV.

IV.

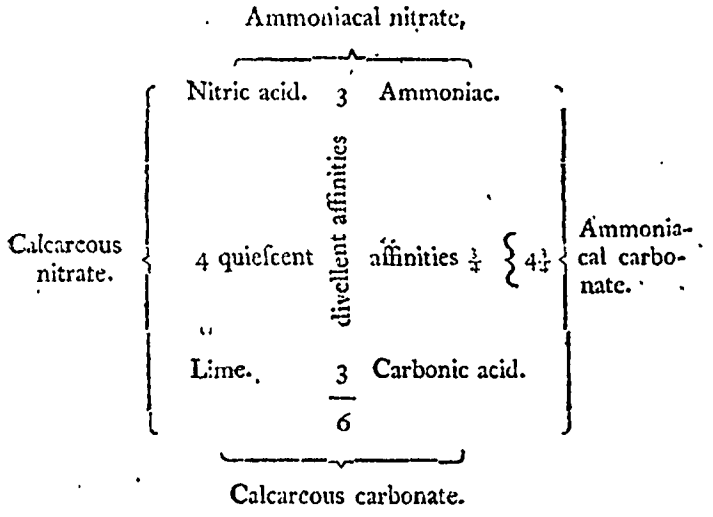

Muriate of ſoda.
Soda. 5 Muriatic acid.
Sulphate of ſoda.
7 quieſcent
divellent affinities
affinities 3
10
Calcareous muriate.
Sulphuric acid. 6 Lime.
11
Calcareous ſulphate.

V.

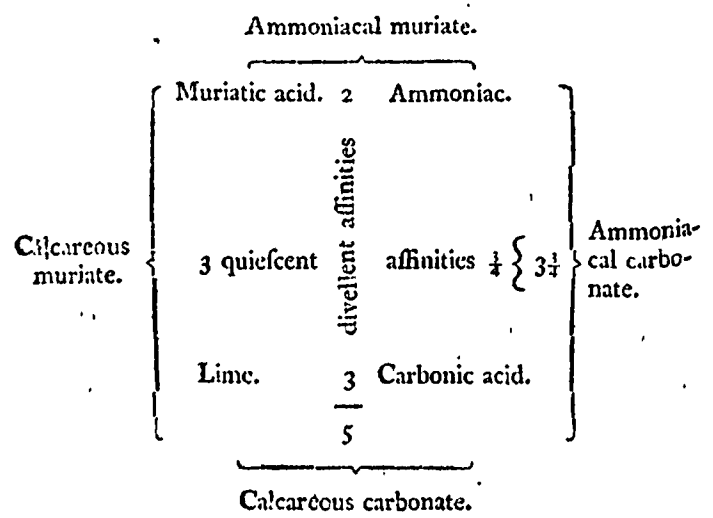

Ammoniacal ſulphate.
Sulphuric acid. 4 Ammoniac.
Calcareous ſulphate.
6 quieſcent
divellent affinities
affinities 1/4
6 1/4
Ammoniacal carbonate, or concrete volatile alkali.
Lime. 3 Carbonic acid.
7
Calcareous carbonate.

VI.

VI.

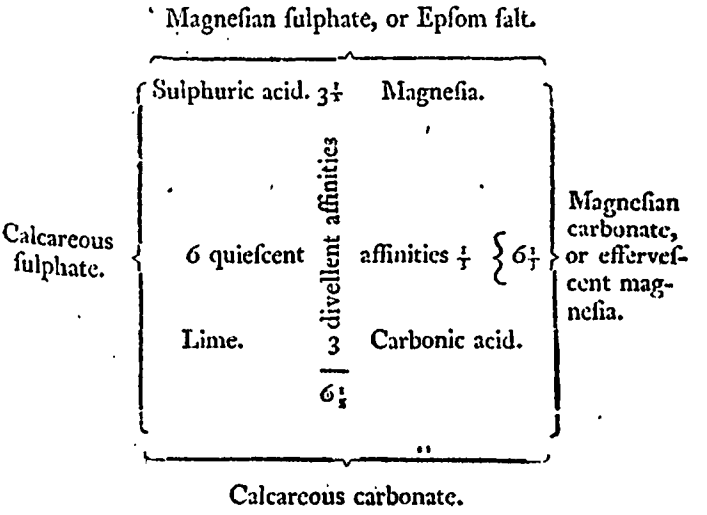

Ammoniacal nitrate,
Nitric acid. 3 Ammoniac.
divellent affinities
Calcareous nitrate.
4 quiescent
affinities ¾
4¾
Ammoniacal carbonate.
Lime. 3 Carbonic acid.
6
Calcareous carbonate.

VII.

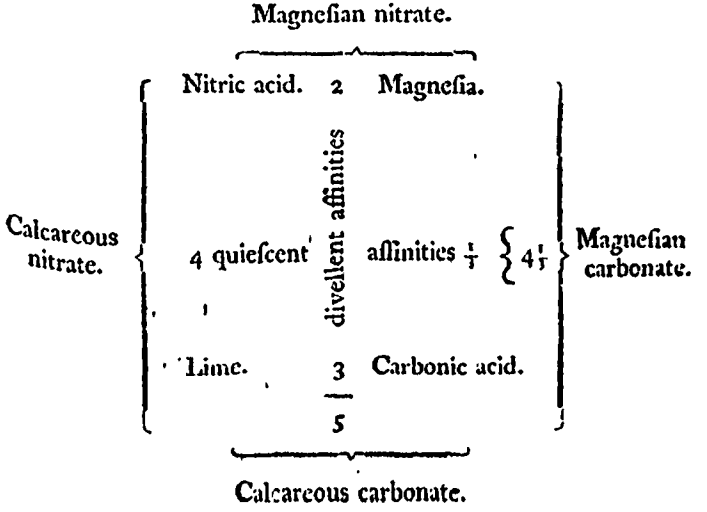

Ammoniacal muriate.
Muriatic acid. 2 Ammoniac.
divellent affinities
Calcareous muriate.
3 quiescent
affinities ¼
3¼
Ammoniacal carbonate.
Lime. 3 Carbonic acid.
5
Calcareous carbonate.

VIII.

VIII.

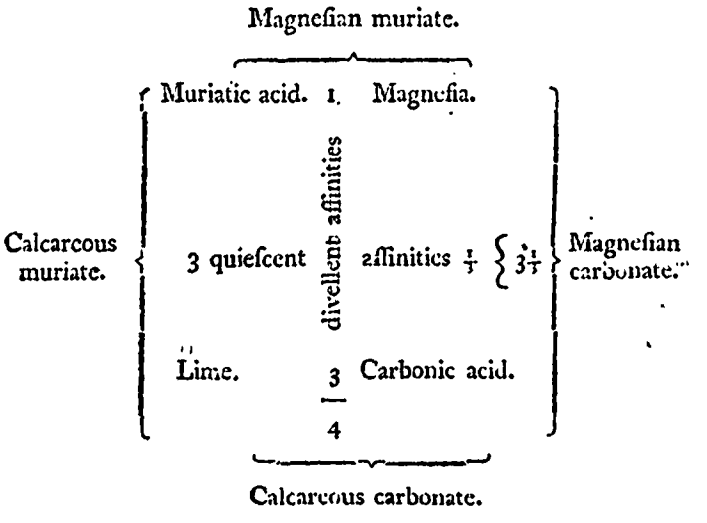

Magnesian sulphate, or Epsom salt.
Sulphuric acid. 3
Magnesia.
Calcareous sulphate.
6 quiescent
divellent affinities
affinities
Magnesian carbonate, or effervescent magnesia.
Lime.
3
Carbonic acid.
Calcareous carbonate.

IX.


Magnesian nitrate.
Nitric acid. 2
Magnesia.
Calcareous nitrate.
4 quiescent
divellent affinities
affinities
Magnesian carbonate.
Lime.
3
Carbonic acid.
5
Calcareous carbonate.

X.

X.



Thefe ten are not the only affinities fubfifting among the neutral falts which we have examined. We have feen, for inftance, that the barytic falts are not decompofed by potafh, but are liable to decompofition by carbonate of potafh, or carbonate of foda; and that calcareous fluate is fubject to the fame laws. Thefe two inftances of double affinity, and perhaps fome others which are but imperfectly known, have not been exhibited in the foregoing table; becaufe we are not fufficiently acquainted with the elective attractions of barytes, and the fluoric acid, to repref ent them by numbers. When the experiments neceffary to make us fufficiently acquainted with thefe affinities fhall have been made, it will no doubt be neceffary to change the numbers, and to adopt others expreffive of the newly difcovered affinities: But the method will ftill remain; it can only be rendered more accurate.

SECTION

SECTION III.

Of MINERALOGY.

Combuſtible Bodies.

CHAP. I.

Of Combuſtible Bodies in general.

WE have already ſpoken of combuſtion in the hiſtory of air. The order which we follow, renders it neceſſary for us to to give here a brief recapitulation of what was before ſaid on this ſubject.

According to Stahl, a combuſtible body is a compound containing fixed fire or phlogiſton. His theory repreſents combuſtion as the diſengagement and paſſage of this fire from a fixed into a free ſtate. Light and heat are ſignals indicating its diſengagement.

When

When the phænomenon ceaſes, the body which has diſplayed it enters into the claſs of incombuſtible matters: by reſtoring its phlogiſton, or by uniting with it the matter of fire fixed in ſome other body, we render it again combuſtible. But this theory is attended with four material difficulties. 1. The exiſtence of phlogiſton cannot be demonſtrated. 2. The weight of combuſtible bodies is conſtantly found to be increaſed after combuſtion; and it is hard to conceive how this can happen to any body when it loſes one of its principles. 3. Another ſtrange circumſtance is, that any body ſhould loſe part of its weight, by that acceſſion of phlogiſton which cauſes it to paſs from an incombuſtible to an inflammable ſtate. 4. Stahl does not appear to have conſidered that air is neceſſary to combuſtion.

A more careful obſervation of the laſt of theſe phænomena, and of the increaſe of weight which bodies acquire during their combuſtion, has given riſe to the following theory.

What renders a body combuſtible is its having a ſtrong tendency to combine with the oxigenous principle, which is the baſe of vital air. Combuſtion is the very act by which this combination takes place; it never happens but when the oxigene loſes the caloric by which it was maintained in a gaſeous ſtate. This opinion is founded on the four following facts: 1. No body can burn without vital air. 2. When the air is pureſt, the act of combuſtion is the moſt rapid. 3. By combuſtion air is abſorbed, and the burnt body gains additional weight. 4. Laſtly, A body burnt in the air acquires a quantity of oxigene equal in weight to

what

what the ſurrounding atmoſphere loſes; which oxigene may be often extracted by methods which we ſhall hereafter deſcribe.

Macquer attempted a reconciliation of this theory with Stahl's, by explaining phlogiſton to be light in a fixed ſtate, and aſcribing to vital air the power of precipitating light. He thought, that in every act of combuſtion, phlogiſton was ſeparated into the ſtate of light by vital air, which occupied its place in the combuſtible body; and he conſidered light and vital air as two ſubſtances which mutually precipitated each other. When fixed light is cauſed to paſs out of a combuſtible body into a body that is already burnt; the vital air, according to this theory, yields its place in the one body to light, and ſeizes that which the light has left unoccupied in the other. But within theſe few years, the chemical doctrine on this head has attained a degree of ſtrictneſs and accuracy which neither requires nor allows our having recourſe to ſuch forced and complicated theories. We may here recapitulate it, in order to repreſent it with ſtill more plainneſs and perſpicuity than before.

Vital air is compounded of a baſe named *oxigene*, which is ſuſceptible of fixation, and is maintained in ſolution in the ſtate of an elaſtic fluid by light and caloric. When a combuſtible body is heated in this fluid, it decompoſes the vital air, and ſeizes its baſe or oxigene. The caloric and light being then ſet at liberty, regain their original rights, and eſcape in poſſeſſion of all their diſtinguiſhing properties; namely, the firſt in the form of heat, the ſecond in the form of flame. According to this doctrine, vital air is the only combuſtible body.

This

This theory does not abſolutely deny the exiſtence of a phlogiſtic principle; for light acts the part which was aſcribed to it. But it differs from Stahl's theory, in repreſenting the phlogiſton which he placed in the combuſtible body, as a principle not of it, but of the body by which combuſtion is maintained. The ſame objection may indeed be made againſt the exiſtence of oxigene which has been urged againſt Stahl's phlogiſton. We are entirely unacquainted with any ſuch principle in a pure or inſulated ſtate: it is always combined with caloric in vital air, or with combuſtible bodies after they have ſuffered combuſtion. Like phlogiſton, it only paſſes from one combination into another; but never diſplays itſelf in a pure ſeparate ſtate. There is, however, a mighty difference between the two theories. The latter, to which we aſcribe truth and accuracy, is founded upon plain facts; the increaſe of weight which a combuſtible body gains, and the diminution of weight which the ſurrounding atmoſphere ſuffers from combuſtion; whereas ingenuity has never been able to eſtabliſh Stahl's theory on ſuch a baſis.

Combuſtible bodies differ in their tendency to combine with oxigene; and it would appear that a body is more or leſs combuſtible, according as it has a nearer or a more diſtant relation to this principle. So that the order in which combuſtible bodies tend to combuſtion may be determined, and a table conſtructed to expreſs their various affinities with the baſe of vital air.

This difference of affinity between combuſtible bodies and oxigene is the cauſe of that diverſity of phæ-

nomena

homena which ſuch bodies exhibit when they enter into combination with this elaſtic fluid.

We may diſtinguiſh four different kinds of combuſtion

1. Combuſtion with flame and heat, as in the inſtance of ſulphur, &c.

2. Combuſtion with heat without flame, as in many of the metals, &c.

3. Combuſtion with flame without heat, as in phoſphori, &c.

4. Slow combuſtion, apparently without either flame or heat; which happens when certain combuſtible bodies are brought into contact with air, or when oxigene fixed in ſome body, and ſeparated from caloric, paſſes unobſerved out of that body into another.

Beſide theſe leading diſtinctions, combuſtion is varied by many other phænomena, peculiar to particular combuſtible bodies. The velocity, the colour, and the extent of the flame, the ſmell which accompanies it, the quantity of oxigene abſorbed, the form, the colour, and the weight of the reſidue of the burnt body, with many other particulars, which it would be improper to enlarge upon here, but which ſhall be conſidered with all the attention they merit, when we give the hiſtory of each combuſtible body by itſelf, form ſo many eſſential diſtinctions, by means of which combuſtible ſubſtances may be diſtributed into claſſes.

When we conſider all the varieties which combuſtible bodies exhibit during their combuſtion, we cannot avoid agreeing that the cauſes from which they proceed are ſtill unknown; and there are ſtill important diſcoveries to be made on this article of the theory of

chemiſtry. The different affinities of combuſtible bodies with the oxigenous principle, may ſerve to explain a part of the phænomena. Indeed it is natural to think that a body having a ſtrong tendency to combine with this principle, muſt afford moſt heat, motion, and light, when the combination takes place; becauſe ſuch a body will ſeparate oxigene from vital air in a more forcible manner than any other whoſe tendency to combine with it is weaker. But yet this doctrine does not account for the diverſity of colour which diſtinguiſhes the flame that proceeds from different inflammable bodies; why, for inſtance, copper gives a green flame, &c. Neither does it explain, not at leaſt in an experimental way, why ſome combuſtible matters burn without giving out any apparent flame, unleſs we agree with ſome philoſophers, that light and heat are the ſame, only the one in a more attenuated, the other in a more condenſed ſtate. But it is well known with what difficulties this opinion is attended. If we reflect, that light is one of the principles of vital air, and is diſengaged during combuſtion, we may perhaps be induced to think that this body is diſengaged in a different manner by different combuſtible matters: that, in ſome inſtances, the whole of light, conſiſting of ſeven rays or principles, is completely diſengaged; while in others, as when nitrous gas acts on combuſtible bodies, only the orange ray is ſeparated; and in others, the green, or yellow, as when zinc and copper act on combuſtible bodies. But this hypotheſis, which has been already mentioned in the hiſtory of combuſtion under the article of *Air*, is ſtill unſupported by experiments. It is enough that

it

it is almoſt demonſtratively proven, that the light diſengaged by combuſtion exiſts not in the combuſtible body, but in vital air. How indeed can we imagine, that a body ſo much attenuated, and ſo elaſtic as light, ſhould be ſuſceptible of fixation and ſolidity? Is not it more natural, and more conſiſtent with ſound philoſophy, to think that light, inſtead of being ſuſceptible of ſolidity, muſt rather poſſeſs the property of deſtroying the ſolidity of ſolid bodies; and that it is one of the cauſes of the elaſticity of vital air, which is nothing but a combination of oxigene, which in a ſeparate ſtate is ſolid, with the caloric principle, and with light?

There are, therefore, ſtill a few difficulties to reſolve in the hiſtory of combuſtion: But it is now ſufficiently proven, that combuſtible bodies, on being burnt, undergo a total change of nature; that the oxigene which becomes fixed in them, in conſequence of their combuſtion, always increaſes their abſolute weight; and that this principle then aſſumes a more ſolid form, than when in combination with caloric and light it conſtituted vital air.

We divide the combuſtible matters of the mineral kingdom into five genera; namely, diamond, hydrogenous or inflammable gas, ſulphur, metallic, and bituminous matters.

CHAP.

CHAP. II.

Genus I. *Diamond.*

DIAMOND is a ſubſtance of a peculiar kind; it is ranked among ſtones, becauſe it poſſeſſes their hardneſs, inſipidity, and inſolubility. It is, beſides, the moſt tranſparent, and the hardeſt of minerals. It is ſo hard, that the beſt tempered ſteel is incapable of penetrating it: nor can diamonds be cut by any other means but by rubbing them on one another.

Diamonds are found in the Eaſt Indies, particularly in the kingdoms of Golconda and Viſapour. We likewiſe get them from Brazil; but the Brazilian diamonds appear to be of an inferior quality: they are known in commerce by the name of *Portugueſe diamonds*.

Diamonds are commonly met with in an ochreous yellowiſh earth, beneath rocks of grit-ſtone and quartz; ſometimes

ſometimes, too, they are found in the beds of rivers; thoſe found in this ſituation have been carried off by the ſtream from diamond mines. Diamonds are ſeldom above a certain ſize. The Indian monarchs keep up the largeſt of them, to hinder their price from falling. Diamonds do not diſplay all their luſtre immediately after being taken out of the earth; they are brilliant only when found in water. All that are dug from mines are covered with an earthy cruſt; and when it is taken off, they exhibit, according to M. Romé de Lille, a ſecond, of the ſame nature with calcareous ſpar.

Diamonds have often an irregular form, and are either flat or round. Sometimes they exhibit regular octohædral cryſtals, conſiſting of two quadrangular pyramids, joined at the baſe; they are likewiſe found with 12, 24, and 48 faces.

Some diamonds are perfectly tranſparent, and of the fineſt water; there are others ſpotted, veined, clouded; theſe are much leſs valuable than the former, Some, again, are uniformly and deeply tinged with yellow, red, blue, or black; but theſe are very rare.

Diamonds appear to conſiſt of laminæ, diſpoſed one over another. They are eaſily ſplit, by ſtriking them with an inſtrument of well-tempered ſteel. But there are ſome diamonds which appear to conſiſt not of laminæ, but of fibres interwoven, ſo as to reſemble the knots of wood. Theſe laſt are ſo very hard, that they cannot be wrought; the lapidaries call them *natural diamonds.*

The tranſparency and hardneſs of the diamond, and the regular cryſtalline form which appears to be moſt

natural to it, induced naturaliſts to rank this ſubſtance among vitrifiable ſtones. They conſidered it as the matter of the pureſt and moſt homogenous rock-cryſtal. They thought it unalterable by fire; becauſe when jewellers heat diamonds ſpotted with yellow, even till they become red, the ſpots are indeed converted to black, but the luſtre of the ſtone is not diminiſhed. Yet diamond was known to be more ponderous and harder than rock-cryſtal, and to poſſeſs electrical properties in a very eminent degree. But theſe peculiarities were aſcribed to its extreme purity.

All tranſparent, ſtony, or ſaline bodies, are known to refract light in the direct ratio of their denſities; but combuſtible bodies refract light in the double ratio of their denſity. The peculiar brilliancy of the diamond appears to depend on its capacity of refracting light in ſo eminent a manner. As it is ſo highly tranſparent, and light is ſo ſtrongly refracted between its lamina, when its ſurfaces are multiplied by cutting, each of its facets affords a ſheaf of very ſplendid light. And therefore thoſe diamonds which are cut into facets all over their circumference, have a much ſuperior luſtre to thoſe which are cut only on one ſide. On this account, lapidaries give the firſt the name of *brilliants*, while they call the others *roſes*.

Boyle aſſerted that fire altered diamonds, and diſengaged from them acrid vapours; but this fact did not immediately engage the attention of philoſophers. But in the years 1694 and 1695, Coſmo III. Great Duke of Tuſcany, ſaw the ſubſtance of diamond entirely deſtroyed by the heat of a burning glaſs. The Emperor Francis

Francis I. likewiſe witneſſed at Vienna the deſtruction of diamond by the fire of a furnace.

M. d'Arcet, in his valuable experiments on ſtony matters expoſed to a violent and continued heat, has not neglected diamonds. He informs us, that vapours iſſue from the ſides of their laminæ; and that if this evaporation be cauſed to ceaſe, what remains of the diamond is found to have ſuffered no alteration of nature, but a diminution of bulk.

M. d'Arcet, wiſhing to know whether the evaporation of diamond was ſimply a decrepitation, contrived to treat it in veſſels variouſly cloſed. He took a ſphere of porcelain paſte, and after cutting it into halves, put a diamond in the middle; he then joined the two ſections nicely together, ſo that the diamond formed to itſelf a cavity within the ſphere, without leaving any void ſpace around it. Putting this ball into an oven, and leaving it there till it was fully burnt, he then broke it, and found the diamond evaporated, and the place which it occupied empty, though he could perceive no chink or fracture any where over the ſurface of the ball.

M. d'Arcet varied this experiment many ways; uſing ſometimes balls of porcelain paſte, ſometimes crucibles of burnt porcelain, ſtopped at the mouth with the ſame matter, and coated over with a fuſible ſubſtance; which being vitrified by fire, ſealed the veſſel hermetically. M. d'Arcet always found the diamond to diſappear; and inferred, that it was ſuſceptible of evaporation without the help of air.

Meſſrs d'Arcet and Roux afterwards obſerved, that ſo intenſe an heat was by no means neceſſary to effect

the volatilization of diamond: And in the year 1770, M. Roux volatilized a diamond in the medical ſchools in five hours, in a cupelling furnace.

In the year 1771, Macquer obſerved a new phænomenon relative to the deſtruction of this ſubſtance. He made uſe of Pott's furnace, on which he had made ſeveral improvements, in volatilizing a diamond, This furnace, when fitted with a pipe or chimney, ten or twelve feet high, produces an heat equal to that of a furnace for hard porcelain. Macquer put a muffle in the middle of his furnace, and the pipe which was fitted to it was only two feet long. He put a diamond, cut into a brilliant, and weighing three-ſixteenths of a carat into a cupel, which he at firſt placed near the mouth of the red-hot muffle; and to prevent the diamond from burſting into pieces, he put the cupel containing it, not at once, but gradually, into the muffle. On obſerving the diamond at the end of twenty minutes, he found it to have increaſed in bulk, and become much brighter than the capſule in which it was placed. At laſt he obſerved a kind of lambent phoſphoric flame, which glowed in a very diſtinct manner around the ſtone; but he could not perceive any of thoſe acrid vapours which Boyle mentions. The diamond being replaced in the muffle, diſappeared entirely at the end of thirty minutes, ſo as to leave no veſtige of it behind. Thus Macquer, in leſs than an hour, volatilized a diamond weighing nearly four grains; and obſerved, that the combuſtion of this, like that of other combuſtible bodies, is attended with a diſcernible flame.

This

This fact, which was firſt communicated to the world by Macquer, has been ſince confirmed by repeated trials. M. Bucquet in the year 1775 volatilized a diamond of about three grains and an half. He made uſe of Macquer's furnace, but without the pipe; and the muffle was left open during all the time of the operation, in order that what paſſed during the combuſtion of the diamond might be ſeen. It continued about five minutes without being inflamed, and the ſpace between the inſtant of its inflammation and its being totally volatilized was five-and-twenty minutes.

As none of theſe experiments ſhowed what became of the diamond, Meſſrs Macquer, Lavoiſier, and Cadet, reſolved to make ſome new experiments on this ſubſtance in cloſe veſſels. They heated twenty grains of diamond in a ſtone retort, fitted with an apparatus proper for retaining the products, if there ſhould be any. They expoſed it to the utmoſt violence of fire without obtaining any product. After the operation, they found the diamonds pretty entire, yet not quite ſo heavy as before. From this circumſtance, they ſuſpected that this loſs of weight was owing to the diamonds being partly burnt, with the help of the ſmall portion of air contained in the veſſels: the diamonds were, beſides, covered over with a blackiſh and ſeeming carbonaceous cruſt, which ſoon diſappeared when they were rubbed on a grind-ſtone.

While chemiſts were employed in experiments on the nature of the diamond, the lapidaries always thought it abſolutely indeſtructible. M. le Blanc, one of theſe artiſts, took a diamond to M. Rouelle to expoſe it to fire, but inſiſted on incloſing it in a way of his own.

own. Accordingly, he put it into a crucible, with a cement of chalk and coal reduced to powder. This crucible was incloſed in another, which was cloſely covered and luted with founder's ſand. It was then put into the fire, and left expoſed to it for four hours. At the end of that time, both M. le Blanc's diamond and others which M. Roulle had expoſed to the fire were vaniſhed. M. Maillard, another lapidary, waited on M. Cadet, when Meſſrs Macquer and Lavoiſier were engaged with him in experiments on this ſubſtance, bringing with him three diamonds, which he propoſed to expoſe to fire after cementing them in his own way. He preſſed the bowl of a tobacco-pipe full of pounded charcoal, and putting his diamonds in the middle, covered the pipe with an iron plate, which he luted to it with founder's ſand. The pipe was put into a crucible lined with chalk, and coated over with ſand wet with ſalt water. The whole was put into Macquer's furnace, and expoſed to ſuch an heat, that at the end of two hours the apparatus was become ſoft and ready to melt. The crucible was now vitrified, and had loſt its ſhape. It was cautiouſly broken, and the pipe was found whole: the charcoal within it was perfectly black, and the diamonds had loſt nothing. They were only a little blackened on the ſurface; but they recovered their whiteneſs and luſtre on being rubbed on a grind-ſtone. Macquer repeated this experiment with the ſame ſucceſs in the great furnace in which the hard porcelain of Sevres is burnt. But, on this occaſion, part of the iron which covered the pipe having been melted, it had reached the diamond, and ſcoriſied it on one

ſide;

ſide; but the other was perfectly unaltered. The fire had been kept up for four-and-twenty hours.

M. Mitouard having had occaſion to expoſe ſeveral diamonds to fire in cloſe veſſels, and with various cements, obſerved, that charcoal was more effectual for preventing the combuſtion of this body than any other matter.

From theſe facts, all chemiſts were led to think, that diamond burns like other combuſtible bodies; and that, like charcoal, it cannot be deſtroyed by fire without being in contact with air. Yet the numerous and accurate experiments of M. d'Arcet appeared to eſtabliſh a contrary doctrine. To determine this matter, Macquer filled ſeveral bowls of burnt porcelain, and ſeveral crucibles of porcelain paſte with powder of charcoal. In the crucibles of unburnt porcelain the charcoal was reduced to aſhes, and the aſhes were even vitrified; but in the veſſels of burnt porcelain the charcoal appeared to have ſuffered no alteration: and he thence concluded, that there is a great difference between theſe two kinds of veſſels. He thinks, that while porcelain is burning, chinks are produced in it, which though ſcarce diſcernible, are ſufficient to facilitate combuſtion; and that, as the porcelain ſhrinks when it cools, all the chinks are cloſed up, and diſappear after it is burnt.

To theſe, M. Lavoiſier has added new experiments, proving, that diamond does not burn unleſs it be in contact with air. He expoſed diamonds to the focus of M. de Trudaine's lens, after covering them with a bell, into which he made water or mercury riſe by emptying it of air. This chemiſt, in experiments on the effects

fects of the burning-glaſs, which he made in conjunction with Meſſrs Macquer, Cadet, and Briſſon, had already obſerved, that when diamonds are ſuddenly expoſed to a ſtrong heat, they crackle and ſcintillate; which never happens when they are ſlowly and gradually heated. He likewiſe obſerved the diamonds to melt in ſome parts of their ſurface: ſuch of them as were for ſome time expoſed to the heat of the lens were penetrated all over their ſurface with ſmall holes, like a pumice-ſtone. When he heated them in the pneumato-chemical machine above deſcribed, he was convinced, that the diamond burnt only for a certain time, in proportion to the quantity of air contained in the bell-glaſs. He examined the air in which the diamond had burnt, and found it preciſely ſimilar to that which remains after the combuſtion of any other combuſtible body; that is, it had loſt that proportion of vital air which renders atmoſpheric air fit for combuſtion. One circumſtance which deſerves to be taken notice of is, that the air which remained after the combuſtion of diamond precipitated lime-water, and contained carbonic acid.

In order to determine with ſtill greater certainty the nature of diamond, M. Laivoſier attempted to burn it under a bell-glaſs filled with carbonic acid. The diamond ſuffered ſome loſs, which was owing no doubt to a portion of air mixed with the acid. He is alſo of opinion, that the loſs which diamond ſuffers on ſuch occaſions is owing to its being volatilized: and he infers from this inſtance, thas this body may be entirely volatilized, if it be incloſed in a cloſe veſſel, and a ſtrong enough heat applied to it. M. Lavoiſier having ſubmitted

mitted charcoal to the ſame operation, obtained a ſimilar reſult, in regard both to its combuſtion and its volatilization. He obſerved too, that the ſurface of diamond always become black.

From theſe facts it follows, that diamond is a ſubſtance very different from ſtones; that it is actually a combuſtible body, which burns with flame whenever it is made red hot in contact with air: in a word, that it is a volatile combuſtible body, for diamond never leaves any fixed reſidue; and that it perfectly reſembles charcoal in the manner in which it is affected by fire; though very different from it in tranſparency, gravity, hardneſs, and many other properties. All of the above experiments, as well as the art of ſplitting diamonds, ſhow, that this body conſiſts of laminæ, or layers arranged one over another; that there is ſometimes between the layers an extraneous colouring matter, to which the carbonaceous coating with which ignited diamonds are covered, eſpecially when in cloſe veſſels, is poſſibly owing. This coloured layer, which is ſometimes nearer to, and ſometimes more remote from, the ſurface, often defeats the attempts of the lapidary to whiten ſpotted diamonds. If it be near the ſurface, it is eaſy to deſtroy it, and render the diamond entirely white. But when it is ſunk deep within the body of the diamond, it is impoſſible to remove it, without deſtroying ſucceſſively the laminæ by which it is covered: and in that caſe, a diamond will be ſometimes entirely deſtroyed before it loſe its colour.

Notwithſtanding all theſe experiments, we know not yet of what principles diamond is compoſed: in the preſent ſtate of our knowledge, it is to be conſidered

ſidered as a peculiar combuſtible body, different from all others.

Diamond is of no uſe but as an ornament: but its property of refracting the rays of light, of decompoſing them, and exhibiting to the eye the moſt brilliant and lively colours, renders it ſo truly valuable, that the eſteem in which it is held is not to be attributed to the caprice of faſhion. Its value is farther increaſed by its exceſſive hardneſs, which enables it to retain the poliſh, its ſcarcity, and the ingenious art with which it is cut. It is uſed for engraving on glaſs and on hard ſtones, and to cut theſe bodies into any required form and ſize.

Diamond-powder is uſed for grinding and poliſhing whole diamonds.

CHAP.

CHAP. III.

Genus II. *Hydrogenous Gas.*

WHAT Dr Prieſtly calls *inflammable air*, and we *hydrogenous gas*, is an aeriform fluid, poſſeſſing all the apparent properties of air. It is about thirteen times lighter than common air; it does not contribute to maintain combuſtion, and it is almoſt inſtantaneouſly fatal to animals by throwing them into high convulſions. It has a ſtrong ſmell. One of its characteriſtic properties is, to take fire when, being in contact with air, an inflammable body is brought near it, or the electric ſpark cauſed to paſs through it.

Hydrogenous gas has been long known both in nature and art. Metal, and coal mines, the ſurface of maſſes of water, and animal or vegetable matters in the ſtate of putrefaction, afford many inſtances of natural, combuſtible vapour. Art has laboured to produce ſimilar vapours, by diſſolving metals with the ſulphuric and muriatic acids, and by diſtilling animal

mal and vegetable ſubſtances. But, before Dr Prieſtley, no perſon thought of collecting thoſe vapours in receivers, in order to examine their properties. He diſcovered that they conſtitute a kind of permanent claſtic fluid.

Hydrogenous gas diſplays all the phænomena characteriſtic of combuſtible bodies in a very eminent degree. Like them, it does not burn but when in contact with air; when pure, it burns with a flame which is more or leſs red; it gives a blue or yellow flame when combined with any ſubſtance capable of modifying its properties. It often crackles, and gives out, when burning, ſmall bright ſparks, with a noiſe ſimilar to that which is produced by the detonation of nitre. It produces, when burning, a lively heat. It is kindled by contact with the electric ſpark.

It burns with the greateſt rapidity when it is ſurrounded with a great quantity of air. As the aggregation of the two fluids is the ſame, it is poſſible to mix them ſo, that a particle of hydrogenous gas ſhall be involved among particles of air; and it then burns with great rapidity. This happens when a mixture, conſiſting of two parts of atmoſpheric air and one of hydrogenous gas, is inflamed. The mixture kindles, burns in an inſtant, and produces a ſmart exploſion like that of gun-powder; but again, hydrogenous gas by itſelf burns but ſlowly, and only at the ſurface.

It may likewiſe be made to burn in an inſtant, and with great violence, by mixing two or three parts of it with one of vital air or oxigenous gas; it then produces

produces a much greater exploſion than in the above inſtance.

Mr Cavendiſh ſome years ago obſerved, that whenever hydrogenous gas is burnt, drops of water always appear. On burning this gas in a veſſel filled with vital air above mercury, a vacuum is produced in the veſſel, the mercury riſes, and great drops of very pure water are ſeen to trickle down the ſides of the veſſel, their quantity ſtill increaſing as the combuſtion goes on. M. Lavoiſier combined ſuch a quantity of theſe two elaſtic fluids as afforded ſeveral drams of water. He took care to make both the fluids paſs through a glaſs cylinder, filled with dry cauſtic fixed alkali, in order to purify them entirely from any portion of water which might be intermixed with them. The weight of the water obtained anſwered exactly to that of the elaſtic fluids conſumed. And he concluded from this experiment, that water is actually a compound of theſe two fluids, in the proportion of ſix parts of oxigene to one of hydrogene. For it is eaſy to underſtand, after what has been already laid down, that the caloric and the light of vital air, and hydrogenous gas, are diſengaged during their combuſtion. And the diſengagement of theſe principles accounts for the weight of water being ſo very different from that of oxigenous or hydrogenous gas. The gravity of water is to that of hydrogenous gas in the proportion of 11,050 to 1, if we ſuppoſe the levity of this gas to be to that of atmoſpheric air in the proportion of 13 to 1: The diſparity will be ſtill greater, if the levity of hydrogenous gas be eſtimated at 16, which may be fairly done when it is perfectly pure.

Water obtained by the combuſtion of vital air with hydrogenous gas is found to contain ſome grains of nitric acid. In order to underſtand how this acid is formed, we may reflect, that Mr Cavendiſh produced nitric gas by combining, through means of the electric ſpark, ſeven parts of vital air with three of gas azote from the atmoſphere.

But the vital air which M. Lavoiſier made uſe of for his experiment was extracted from a red precipitate, or mercurial oxide precipitated by the nitric acid; and that oxide might perhaps afford the ſmall portion of azote which enters into its compoſition; wherefore the nitric acid obtained in this experiment is not to be conſidered as in any degree falſifying the aſſertions of M. Lavoiſier concerning the production of water. If with this fine experiment we compare that by which the ſame chemiſt decompoſed water, by making it fall on red iron, zinc, and coals, as well as boiling oils, and obtained a quantity of the hydrogenous gas proportioned to the quantity of the body burnt, we ſhall find good reaſon to conclude, that the theory of the compoſition of water is as well ſupported as any other chemical theory.

The proportion in which the component principles of water are united in it, appears from the moſt accurate experiments to be 85 parts of oxigene to 15 of hydrogene in weight.

We want only one thing, to know the nature of hydrogenous gas. Is it a ſimple ſubſtance, or a compound ſubject to no varieties, but always the ſame in ſpecies? May it be conſidered as the phlogiſton of Stahl, which

ſeveral

ſeveral Engliſh chemiſts, at the head of whom is Mr Kirwan, have thought it to be?

With regard to the firſt queſtion, it is nearly agreed among chemiſts, that all ſubſtances, however different in nature, which contain inflammable gas, afford it preciſely the ſame in all its properties.

There are indeed ſome who ſtill acknowledge ſeveral ſpecies of inflammable gas; ſuch as the inflammable gas obtained from iron and zinc by water, which burns with a red flame, and detonizes with pure air; that which M. de Laſſone obtained from Pruſſian blue, and from the reduction of flowers of zinc by charcoal, which burns in air without detonization; the inflammable gas that riſes from marſhes, and burns with a blue flame, without detonization; and that which is obtained by the diſtillation of organic matters, and reſembles the gas of marſhes. But we have learned from a ſtrict analyſis of the two laſt, that they are compounds of genuine, pure, and detonating hydrogenous gas, with gas azote and carbonic acid in various proportions. In the year 1782, I was led to think, with the illuſtrious Macquer, that there is only one ſubſtance of this kind, which, by combining with different ſubſtances, undergoes various modifications. The experiments of many celebrated natural philoſophers, particularly of Cavendiſh, Prieſtley, Watt, Kirwan, Lavoiſier, Monge, Berthollet, de Morveau, &c. have ſince eſtabliſhed the truth of this opinion. The mixtures of the other gaſes, and the ſolution of coal, ſulphur, and phoſphorus in hydrogenous gas, the weight of which they augment, and render it leſs combuſtible, afford us reaſon to think, that the ſeeming

varieties of inflammable gas are owing to ſuch mixtures or combinations. To me therefore it appears to be at preſent fully demonſtrated, that there is only one ſpecies of inflammable gas, produced by the decompoſition of water, and capable of producing water by combining with vital air; in a word, that there are no ſpecies belonging to this genus but hydrogenous gas, which is more or leſs inflammable, and variouſly coloured, according as it is mixed or combined with other bodies.

As to the ſecond queſtion; there are indeed ſeveral facts which appear to ſupport the opinion of Bergman and the Engliſh chemiſts, who take hydrogenous gas to be Stahl's phlogiſton; but there are many more which oppoſe our adopting that opinion. It appears that the combuſtible ſubſtances in which Stahl allowed the exiſtence of phlogiſton, do not all afford this elaſtic fluid, and that water always contributes to its formation. Mr Kirwan, who has been engaged for ſeveral years in examining this important queſtion, has not yet, as far as we know, been able to determine it by any deciſive experiment. Under ſome other articles of this work we will give our opinion of the hydrogenous gas, which that celebrated chemiſt obtained from an amalgam of zinc, as well as of ſome other analogous experiments, which have been urged by ſeveral philoſophers againſt the doctrine which we advance. We will not here enter into a detail of the objections which may be made to it; for we might poſſibly not be underſtood by thoſe whoſe ſtudies in chemiſtry have not extended farther than the foregoing chapters of our work; but thoſe objections ſhall be ſtated in the chapters

ters concerning metallic ſubſtances, phoſphorus, &c. However it be, we muſt here acknowledge the phænomena may be explained on the ſuppoſition that hydrogene is the ſame with phlogiſton; but we cannot help obſerving, at the ſame time, that the theory of phlogiſton requires to ſupport it ſome forced and improbable ſuppoſitions, and is far from being equally ſimple and ſatisfactory with that which we have adopted as the plain ſimple reſult of facts*.

No chemiſt has yet analyſed hydrogenous gas into principles; it is to be conſidered as a ſimple ſubſtance in the preſent ſtate of our knowledge; hydrogyne, its baſe, combines entirely with pure air, or oxigene; and water is formed by the combination. The reader will obſerve, that we have ſaid nothing of the theories of thoſe writers, ſome of whom have aſſerted inflammable gas to be a compound of air with the matter of fire, while others repreſent it as a modification of light, fire, the electric fluid, &c. Theſe aſſertions are too vague, bear too great a reſemblance to the inaccurate and ambiguous language of the infancy of natural philoſophy, and are too inconſiſtent with experiments, to merit a ſerious diſcuſſion. According to Mr Kirwan, Dr Crawford has ſhewn, that hydrogenous gas contains a greater proportion of light and caloric, than vital air contains; and that the proportion of light and caloric in theſe two gaſes, is that of 24 to 1: It would be of great uſe to aſcertain how much of theſe principles hydrogene loſes when it enters into ſolid or liquid combinations.

* See Mr Kirwan's work on this ſubject; or the French tranſlation of that work, with notes added. F. This was written before Dr Kirwan had declared himſelf a convert to the French theory. H.

binations. Hydrogenous gas, no doubt, contains a good deal of ſpecific heat or caloric, perhaps even of the matter of light; nor is it always ſeparated from theſe gaſeous matters whenever it loſes its ſtate of elaſticity, and paſſes into liquid combinations.

Hydrogenous gas does not combine with water; it may be long kept under that fluid, without ſuffering any alteration. At length, however, it is ſo much altered, as to be no longer ſuſceptible of inflammation. Dr Prieſtley has not determined the nature of this change, nor the ſtate of the water which produces it. Probably, if ſuch an experiment were carefully performed, it would throw much light on the nature of this combuſtible body.

Hydrogenous gas is not known to act either on earths or on any of the three ſalino-terrene ſubſtances; but it deſtroys the whiteneſs of barytes, and communicates to it a colour; which has cauſed it to be conſidered as the calx or oxide of ſome metal ſtill unknown.

We know not what effects the alkalis and the acids are capable of producing on this gas, nor what changes it produces on them. It would probably decompoſe ſome acids, particularly the ſulphuric acid and the oxigenated muriatic acid, by combining with their oxigene to form water. As to the ſulphuric acid, there is reaſon to think it liable to ſuch a decompoſition; for as ſulphur does not decompoſe water, (a fact of which we will afterwards have occaſion to take notice), the baſe of vital air has certainly a ſtronger affinity with hydrogene than with ſulphur. The oxigenated muriatic acid has ſo conſiderable an exceſs of oxigene, and that ſo imperfectly united with it, that we may with

good

good reaſon think that hydrogenous gas would carry off part of it to form water.

Hydrogenous gas does not ſeem capable of acting on neutral ſalts; but its influence on ſaline ſubſtances in general has not yet been examined.

This gas is become a ſubſtance of much more conſequence than formerly, ſince it has been made uſe of to fill aeroſtatic machines; a diſcovery which we owe to Meſſrs Montgolfier. Its ſpecific levity, which is thirteen times greater than that of air, cauſes thoſe machines to riſe in the atmoſphere. It is more than probable that it performs an important part in all the phænomena of meteors; that there is a great quantity of it diffuſed through the atmoſphere; and that the electric ſpark kindles it, and cauſes it to produce water. Perhaps it is carried about in the winds as a kind of natural aeroſtatic.

Attempts have been made to ſubſtitute it in the room of other combuſtible matters for ſome of the purpoſes of life; to give light and heat, and to diſcharge fire-arms, &c. M. Volta has conſidered it in this laſt point of view, and has propoſed ſeveral ways of making uſe of it. M. Nerete, in the *Journal de Phyſique* for January 1777, has given a deſcription of a chaffing-diſh with inflammable gas. M. Furſtenberger, a natural philoſopher at Bale, M. Brender, an ingenious mechanic of Augſburgh, and M. Ehrman Lecturer in Natural Philoſophy at Straſburgh, have contrived lamps which may be kindled at night by means of the electric ſpark. Laſtly, Artificial fires, affording a very agreeable ſpectacle, are made with glaſs tubes, va-

rioufly bent, and pierced with a great may holes. Inflammable gas is introduced into theſe tubes from a bladder full of it, through a copper cock. When the bladder is preſſed, the inflammable gas paſſes into the tube, iſſues out through all the holes, and is kindled by a burning taper.

CHAP.

CHAP. IV.

Genus III. *Sulphur.*

SULPHUR is a combuſtible body; dry, very brittle, of a citron yellow colour, entirely without ſmell, except when it is burnt, and of a peculiar taſte, which is weak, though perceptible enough. When rubbed, it becomes electric. When a large piece of it is expoſed to a moderate but ſudden heat, as for inſtance, by being compreſſed in the hand, it crackles and breaks into pieces.

Sulphur abounds in nature; ſometimes it is found pure, and ſometimes in combination with other ſubſtances. It is our buſineſs here to ſpeak only of the former. The following are the varieties of pure ſulphur.

Varieties.

Varieties.

1. Tranſparent ſulphur in octohædral cryſtals, with two truncated pyramids. It is generally depoſited by water on the ſurface of a calcareous ſpar. Cadiz ſulphur is of this kind.
2. Tranſparent ſulphur in irregular fragments. The ſulphur of Switzerland is in this ſtate.
3. Whitiſh purverulent ſulphur, depoſited in ſiliceous gæodes. There are flints found in Franche-Compté, &c. full of ſulphur.
4. Pulverulent ſulphur, depoſited on the ſurface of mineral waters; ſuch as thoſe of Aix-la-Chapelle, of Enghien near Paris, &c.
5. Cryſtalline ſulphur that has been ſublimated; the cryſtals are tranſparent; it is found in places adjacent to volcanoes.
6. Pulverulent ſulphur ſublimated by volcanoes; its form is irregular, and it is often intermixed with ſoft ſtones, as may be obſerved at Solfatara, in the neighbourhood of Naples.
7. Sulphur in ſtalactites, formed by volcanic fires.

Beſide theſe ſeven varieties of pure mineral ſulphur, this ſubſtance is found in combination with various other matters. It is moſt frequently united with metals, which are then in the ſtate of *pyrites*, or metallic ſulphures and ores. Sometimes it exiſts in combination with calcareous matters in the ſtate of earthy ſulphure or liver of ſulphur; fetid calcareous ſtones and ſwine-ſtone appear to be of this nature.

Recent diſcoveries extend the empire of this mineral ſtill farther. It ſeems to be daily formed in animal and

and vegetable matters beginning to putrefy. Though theſe ſpecies of ſulphur belong not properly to the mineral kingdom; yet, to complete the natural hiſtory of this ſubſtance, we ſhall ſubjoin them to the preceding varieties.

Varieties.

8. Sulphur in cryſtals, formed by the ſlow decompoſition of an accumulation of animal-matters. Such is the ſulphur found in the old lay-ſtalls, near the gate of St Anthony.
9. Pulverulent ſulphur, formed by vapours ariſing from animal matters in the ſtate of putrefaction; it is found on ſtable-walls, and in privies, &c.
10. Sulphur extracted from various vegetables, particularly from dock-root, from ſpirit of cochlearia, &c. For this diſcovery we are indebted to Meſſrs Baumé and Deyeux, members of the College of Pharmacy, and Lecturers in Chemiſtry, &c.
11. Sulphur obtained by M. Deyux by an analyſis of animal matters, particularly of the white of an egg.
12. Sulphur obtained from horſe-dung. This combuſtible body has been found in horſe-dung at the inſtant of its emiſſion. Very probably future obſervation may diſcover it in many other animal matters.

But none of all theſe varieties of ſulphur is that which is uſed in the arts. This ſulphur is extracted by

by diſtillation from metallic compounds, of which it is a principle, and which are called *pyrites*. In Saxony and Bohemia, it is put into earthen tubes in ſmall pieces, and thus placed on an oblong furnace. One end of the tube ſtands in the furnace, and the other paſſes into a ſquare veſſel of caſt-iron containing water. The ſulphur accumulates in this receiver; but it is very impure. To purify it, it is melted in an iron ladle; the earthy and the metallic parts are then precipitated. It is next poured into a copper boiler, in which it is farther purified by depoſiting other extraneous matters. After being kept here in fuſion for ſome time, it is poured into cylindrical wooden moulds, which give it the form in which we uſually ſee it in commerce. The precipitate which ſubſides to the bottom of the boiler while it is in fuſion, is grey and very impure. It is very improperly called *quick ſulphur*. In other places, as at Rammerlſberg for inſtance, ſulphur is extracted from pyrites by a ſimple proceſs. The ſulphur of maſſes of pyrites roaſted in the open air, is taken off in ladles, and purified by a ſubſequent fuſion.

Sulphur ſuffers no alteration from the contact of light. When heated in cloſe veſſels, it becomes ſoft, and melts; and when afterwards cooled, it generally aſſumes a red, a brown, or a greeniſh colour, and a needle form. The proceſs by which M. Rouelle cryſtallized it, was ſuffering the ſurface to congeal, and afterwards pouring off the fluid beneath: the under ſurface of the cruſt then exhibited the ſulphur in needles croſſing each other in various directions.

When

When melted ſulphur is gently heated, it volatilizes in ſmall pulverulent parcels of a citron yellow, which are called *flowers of ſulphur*. This operation is employed ſucceſsfully to purify ſulphur, though it is the pureſt part which is volatilized. For performing this operation, common ſulphur in powder is put into an earthen cucurbite, which is fitted with earthen pots inſerted one in another, and known by the name of *aludels*. The uppermoſt of theſe pots is terminated by a reverſed funnel; the opening of which forms a ſlight communication between the interior part of the cucurbite and the air. The cucurbite is then heated till the ſulphur become liquid; which at that degree of heat is ſublimated, and fixed on the ſides of the aludels.

Flowers of ſulphur, when prepared in the great way, often contain a little ſulphuric acid, which is formed by the combuſtion of a ſmall quantity of the ſulphur, in conſequence of the veſſel's containing a ſmall portion of air. They may be entirely purified by waſhing them. The ſulphur made uſe of in medicine, and in nice chemical experiments, ſhould be prepared in this manner.

When ſulphur is heated in ſuch a way that air has acceſs to it, it kindles and burns with a blue flame as ſoon as the heat cauſes it to melt, if the heat to which it is expoſed be but inconſiderable; but when expoſed to a ſtrong heat, it gives a lively white flame. In the firſt of theſe inſtances it diffuſes a ſuffocating ſmell; and by collecting the vapours which exhale from it, we obtain a portion of very ſtrong ſulphurcous acid. When it burns rapidly it has no ſmell, and the reſidue is not ſulphureous, but ſulphuric acid. Stahl, who thought

thought ſulphur to be a compound of this acid with phlogiſton, imagined, that when burnt it loſt its inflammable principle, and was of conſequence reduced to an acid. He has collected ſuch a number of facts in ſupport of his opinion, as could not but prevail with ſucceeding chemiſts to adopt it. But ſince chemiſts have begun to attend to the influence of air in combuſtion (a circumſtance to which Stahl appears to have paid ſcarce any attention), ſeveral of them, ſtruck with the difficulty which has hitherto been found in all attempts to prove the exiſtence of phlogiſton, and with the facility with which all objections againſt that doctrine may be anſwered by means of the late diſcoveries concerning the nature of air, have adopted an opinion directly oppoſite to Stahl's concerning the nature and the combuſtion of ſulphur.

The following are the facts on which this new opinion is founded. Hales obſerved, that ſulphur abſorbs a great quantity of air when it burns. M. Lavoiſier has ſhown that ſulphur is ſubject to the ſame laws with other combuſtible bodies: 1. It cannot burn, except vital air have acceſs to it. 2. During its combuſtion, it abſorbs the pureſt part of that air. 3. That part of atmoſpheric air which remains after it has contributed to the combuſtion of ſulphur, can no longer ſerve the ſame purpoſe. 4. The ſulphuric acid produced by the combuſtion of ſulphur is equal in weight not only to the quantity of ſulphur, but alſo to the portion of air that has been conſumed. 5. Conſequently ſulphur muſt combine with the baſe of pure air, or oxigene, in order to form ſulphuric acid. This acid is therefore a compound of oxigene with ſulphur; and the laſt of

theſe

theſe is not a compound body, but one of the principles of the ſulphuric acid. It forms the acid by combining with the baſe of vital air or oxigene; and this combination takes place when it is expoſed to combuſtion. Heat is neceſſary to make it burn; for, by dividing it, and deſtroying its aggregation, it promotes its combination with oxigene. When once burnt, or combined with oxigene, it is no longer ſuſceptible of inflammation, but becomes an incombuſtible body.

It abſorbs various quantities of oxigene, and becomes more or leſs acid, according to the manner in which it is burnt. Such is the theory of the difference between the ſlow and the rapid combuſtion of ſulphur, and between the ſulphureous and the ſulphuric acids, which are produced by theſe combuſtions. Stahl thought, that when ſulphur burnt ſlowly, it did not loſe all its phlogiſton; and that the ſulphuric acid was odorous and volatile in conſequence of its retaining part of it. It is now experimentally proved, that when ſulphur burns ſlowly, it does not abſorb the full quantity of oxigene, with which it is capable of uniting; but when it burns rapidly, it abſorbs as much of this principle as is neceſſary for the formation of the ſulphuric acid. The ſulphureous acid, in combination with alkaline matters, paſſes into ſulphuric acid, by abſorbing gradually the baſe of vital air from the atmoſphere.

This theory ſerves equally to explain what happens when ſulphur is formed by the combination of the ſulphuric acid with certain combuſtible matters, as in the inſtances we have already mentioned, with ſulphate of

potaſh

potaſh and of ſoda, with ammoniacal, calcareous, magneſian, aluminous, and barytic ſulphate, when heated with coal. The combuſtible body ſeizes the oxigene contained in the ſulphuric acid, and leaves only the ſulphur, which is its other principle. Whenever, therefore, the ſulphuric acid is converted into ſulphur by a combuſtible body, the latter is conſtantly reduced to the ſtate of a burnt body, as we ſhall have occaſion to ſee in the hiſtory of ſeveral of the metals. On this account a large quantity of carbonic acid is obtained, when ſulphur is artificially produced, as the oxigene of the ſulphuric acid is united with the pure carbonaceous matter. The reader may recollect, that the exiſtence of oxigene, or the baſe of pure air in the ſulphuric acid, is eaſily demonſtrable. Various attempts have been made to determine by experiment the proportions in which oxigene and ſulphur are combined in the ſulphuric acid, in the ſame manner as the proportions of the nitric, the carbonic, and the phoſphoric acids have been determined.

Sulphur is neither liable to any alteration from air, nor ſoluble in water. If, after being kept in fuſion till it becomes thick, it be poured into water, it then becomes red, and retains a certain degree of ſoftneſs, ſo that it may be kneaded in the hand; but in a few days it loſes theſe properties. Water dropped on ſulphur does not ſeem to be decompoſed, nor contribute to the combuſtion of the ſulphur; from which it appears, that the baſe of vital air or oxigene has a greater affinity with hydrogene than with ſulphur. This aſſertion is confirmed by the manner in which hydrogenous

gas

gas acts on the ſulphuric acid, for it robs it of its oxigene.

Sulphur does not act at all on ſiliceous earth; it combines with aluminous earth, but not without great difficulty. This earth, however, when it is very much attenuated, appears to reduce ſulphur to the ſtate of an hepar or fetid ſulphure, as may be obſerved in the preparation of pyrophorus.

A compound of ſulphur with alkaline matters, is generally called *alkaline ſulphure*, *hepar*, or *liver of ſulphur*. This compound is generally of a lighter or a deeper brown colour, like the liver of animals: vital air decompoſes it; water diſſolves it, cauſing it to give out a fetid ſmell; the acids precipitate the ſulphur, extricating from it a peculiar gas, which was at firſt named *hepatic gas*; but to which, in alluſion to its nature, we now give the name of *ſulphurated hydrogenous gas*. There are ſix ſpecies of alkaline ſulphures produced by barytes, magneſia, lime, the two fixed alkalis, and ammoniac or volatile alkali. We may examine the properties of each of theſe by itſelf.

Pure barytes does not act ſtrongly on ſulphur, when they are heated together in water; the product is a weak ſulphurated or hepatic liquor: but in the dry way, the two bodies enter into a much more intimate combination. Therefore, when a mixture, conſiſting of eight parts of barytic ſulphate in powder with one part of coal, is expoſed in a crucible to a ſtrong heat; an incoherent maſs is obtained without fuſion, which readily diſſolves in warm water, and has the ſmell and all the other characteriſtics of an hepar. The ſolution is of an orange or golden yellow colour. I have diſcover-

ed that it cryſtallizes by cooling. Barytic ſulphure in cryſtals is of a yellowiſh white colour: when expoſed to the air, it attracts moiſture from it, aſſumes a deeper colour, and is decompoſed; for ſome part of the ſulphur is precipitated, and barytic ſulphate formed. This ſulphure, when precipitated by acids, gives out an elaſtic fluid, known by the name of *ſulphurated hydrogenous gas*, which has been mentioned above, and the peculiar properties of which we will afterwards examine. When barytic ſulphate is precipitated by the ſulphuric acid, the precipitate is found to conſiſt of both ſulphur and barytic ſulphate; but when the nitric, or the muriatic acid is employed, the barytic nitrate or muriate remains in ſolution, and only the ſulphur ſubſides.

Sulphur combines with pure magneſia with the help of heat. The neutral ſalt, which we call *carbonate of magneſia*, is commonly uſed for this combination, as diſſolving the moſt readily in water. A ſmall portion of magneſian carbonate, with an equal quantity of flowers of ſulphur, are put into a bottle full of diſtilled water. This veſſel, entirely emptied of air, and cloſely ſtopped, is expoſed for ſeveral hours to the heat of a balneum mariæ; the water is then filtrated; it has the fetid ſmell of rotten eggs; it communicates an high colour to ſolutions of metals; it gives by ſpontaneous evaporation, ſmall cryſtalline needles; in a word, it is a genuine magneſian ſulphure. The magneſia may be precipitated by one of the fixed alkalis,—which have a greater affinity than it with ſulphur. The acids ſeparate the ſulphur in the form of a white powder; from which its exiſtence in this mixture is certainly known.

Such

Such was the liver of ſulphur which M. le Roi, phyſician at Montpelier diſſolved in pure water, in order to form an imitation of ſulphureous mineral waters. But it is now known, that ſcarce any of theſe waters contains genuine ſulphure; they are mineralized by ſulphurated hydrogenous gas.

Lime unites with ſulphur with much more rapidity and eagerneſs than either of the two former ſalino-terrene ſubſtances. When a little water is ſlowly poured on a mixture of quicklime with ſulphur in powder, the heat diſengaged by the action of the water on the lime, occaſions a combination between the lime and the ſulphur. If more water be added, the mixture aſſumes a reddiſh colour, and exhales a fetid odour. It retains in ſolution, the ſulphur in combination with the lime. It is difficult to prepare this calcareous ſulphure in any other way but the humid. When the lime is not very cauſtic, and does not produce much heat on coming into contact with water; it is often found neceſſary to aſſiſt the combination by a moderate fire. This compound is of a lighter or a deeper red, according to the cauſticity of the lime. I have obſerved, that when the ſolution is much concentrated, it depoſites, by cooling, a layer of ſmall needle cryſtals, of an orange yellow, arranged in tufts, which to me appeared to be compreſſed tetrahædral priſms, terminating in dihædral ſummits. In the air theſe cryſtals gradually loſe their colour, and become white and opaque, without ſuffering any alteration of form. Calcareous ſulphure, moiſtened with a little water, and diſtilled in a pneumato-chemical machine, is decompoſed in part, and affords a large proportion of ſulphurated hydrogenous gas. If evapo-

rated to dryneſs, and calcined in a crucible till it ceaſe to fume, what remains after the operation, is calcareous ſulphate formed by lime and the ſulphuric acid produced by the ſlow combuſtion of the ſulphur. Calcareous ſulphure is very ſoon altered by air; as its gas flies off, it loſes its ſmell and colour. When diſſolved in a large quantity of water, it ſuffers the ſame alteration; eſpecially if it be ſhaken, as M. Monnet has obſerved in his Treatiſe on Mineral Waters; what remains after theſe alterations is calcareous ſulphate. If preſerved in bottles, partly empty, it depoſites a blackiſh cruſt on the ſides of the bottles, and cruſts or pellicles are from time to time formed, which ſink to the bottom of the liquor. If the veſſel containing it be cloſely ſtopped, it remains long unaltered, as I have often obſerved in my own laboratory. I know of ſome of this preparation which was made up 15 years ago, and which ſtill retains its colour and ſmell, and affords a copious precipitate when acids are applied to it. Calcareous ſulphure is decompoſed by the pure fixed alkalis, which have a greater affinity with ſulphur than ſulphur has with lime. Acids precipitate the ſulphur in the form of a very fine white powder, which has received the name of *magiſter of ſulphur*. The carbonic acid effects this precipitation, as well as the reſt of the acids. The manner in which neutral ſalts act on calcareous ſulphure is unknown.

The two fixed alkalis, in a pure or cauſtic ſtate, act in a very remarkable manner on ſulphur. They form with it thoſe ſulphures which are moſt permanent and leaſt liable to decompoſition. I have diſcovered that the fixed alkalis when dry and very cauſtic, act upon

ſulphur

ſulphur even cold. All that is requiſite to promote this phænomenon, is to triturate ſolid potaſh or ſoda in a mortar with powdered ſulphur. The mixture becomes ſoft, aſſumes a yellow colour, exhales a fetid odour, and forms a ſulphure. But when it is diſſolved in water, the ſolution is only of a pale yellow colour, and does not contain ſo great a quantity of ſulphur as the ſame ſulphure prepared with heat. Alkaline ſulphure is prepared in two ways in the laboratory,—the dry, and the humid way. The following are the particulars of the firſt proceſs: Equal parts of pure and ſolid potaſh or ſoda and powdered ſulphur are put into a crucible; heat is then applied till the mixture be entirely heated; when in fuſion, it is poured on a plain marble ſurface; and when cooled, it diſplays a deep red colour, like the liver of an animal. M. Gengembre, who has read before the academy an account of ſome very valuable experiments on ſulphurated hydrogenous gas, has made an important obſervation on alkaline ſulphure prepared in the dry way. It is, that this compound is not at all fetid, and exhales no ſulphurated hydrogenous gas while it continues dry. Till it be diſſolved in water, or attract moiſture from the atmoſphere, it never gives out any ſmell; from which circumſtance it appears, that the diſengagement of the fetid gas is effected by water, as we ſhall afterwards more particularly explain. The two fixed alkalis, when pure and cauſtic, act preciſely in the ſame manner on ſulphur, diſſolving it likewiſe in the dry way. Theſe combinations of the cauſtic alkalis with ſulphur have as yet been but very little examined; alkaline ſulphure has been almoſt always compoſed with fixed alkali, ſa-

turated with the carbonic acid. There are, however, conſiderable differences between theſe two ſulphures. Firſt, thoſe which are made up with effervescent fixed alkali, require more time to be taken up in the preparation; for fixed alkali is leſs active in this ſtate than when pure. But the moſt important difference which we have had occaſion to obſerve, as ſubſiſting between ſulphures made up with cauſtic fixed alkali, and thoſe made up with effervescent fixed alkali in the dry way, is the comparative ſtate of their ſaturation. The former are more fetid, and browner, when diſſolved, and the gas which they afford is much more inflammable than that given out by the others. The latter are of a paler colour, which is often a greeniſh grey; their ſmell is fainter, and their compoſition leſs laſting. It appears that the fixed alkalis retain a portion of carbonic acid, when in union with ſulphur; for the gas of thoſe ſulphures, in which ſulphur is united with alkaline carbonate, is not inflammable till after being waſhed in lime-water, which carries off the acid. In the preſence of this acid, therefore, and in its power of enfeebling the cauſtic qualities of alkali, we find the cauſe of thoſe appearances which diſtinguiſh cauſtic ſulphures from ſuch as are not cauſtic.

Solid alkaline ſulphure, compoſed with either of the cauſtic fixed alkalis, is extremely fuſible; air decompoſes it like calcareous ſulphure. When heated in cloſe veſſels, after being moiſtened with a little water, it affords a large proportion of ſulphurated hydrogeneous gas. After being melted, it may be cryſtallized by cooling; but its cryſtallized form has not yet been well deſcribed. While hot and dry, it is of a brown colour;

colour; in proportion as it cools, and attracts moiſture from the air, it loſes that colour, and becomes paler; in a ſhort time air cauſes it to aſſume a greeniſh yellow colour; it is again diſſolved into a liquid, and becomes, after ſome time, ſulphate of potaſh or of ſoda. It diſſolves eaſily in water; and immediately begins to exhale a peculiar fetid odour. The odorous gas, which before had no exiſtence, is now formed by the re-action of the water. This ſolution has a deep red, or a green colour, according as the alkaline ſulphure is newly prepared or old. Alkaline liver of ſulphur or ſulphure, prepared in the humid way; by heating in a matraſs, cauſtic fixed alkali diſſolved in water, with a quantity of ſulphur in powder equal to half its weight; exhibits the ſame properties as this ſolution; and we may give the hiſtory of both at once under the common name of *liquid alkaline ſulphure.*

Liquid alkaline ſulphure, when highly concentrated, depoſites by cooling, irregular needles. It is liable to decompoſition by the action of heat; when diſtilled in a pneumato-chemical machine, it gives ſulphurated hydrogenous gas. Air likewiſe decompoſes it; and it is then covered with pellicles, and depoſites ſulphur, and becomes turbid. Bergman and Scheele have proved this decompoſition to be owing to the vital air diffuſed through the atmoſphere. In fact, when a little liquid alkaline ſulphure is put into a bell-glaſs containing vital air, the oxygene is entirely abſorbed, and the vital air decompoſed Scheele has even propoſed this as an eudiometer: and it is now acknowledged to be one of the beſt.

Neither the earths nor the ſalino-terrene ſubſtances act upon liquid alkaline ſulphure when it is very pure: but, when it has been prepared with carbonate of potaſh or ſoda, lime-water renders it turbid. The acids decompoſe it, by combining with the alkali, and precipitate the ſulphur in the form of a fine white powder. The nitric acid, according to M. Prouſt, produces a detonation, when it is poured on ſolid alkaline ſulphure. When any large quantity of the oxigenated muriatic acid is poured on a ſolution of alkaline ſulphure, it does not produce any precipitate, or at leaſt but a very trifling one; becauſe it diſſolves the ſulphur again, in conſequence of its oxygene being nearly free, and uniting ſo rapidly with that combuſtible body ſo as to convert it into ſulphuric acid. The certainty of this fact may be farther proved by pouring a portion of barytic muriate into the mixture; a copious precipitate of barytic ſulphate is then produced. All the acids, when they decompoſe this ſulphure, cauſe it to give out a gas, which may be collected into a pnuemato-chemical machine, and is worthy of a particular examination.

In order to obtain this gas, an acid muſt be poured on alkaline ſuphure in powder; a lively effervescence is then produced, which would not take place in the ſame manner if the acid were poured into a ſolution of the alkaline ſulphure. This phænomenon, which has not yet ſufficiently engaged the attention of chemiſts, depends upon two circumſtances. 1. Solid alkaline ſulphure does not contain hepatic gas or ſulphurated hydrogene ready formed, as has been obſerved by M. Gengembre; and when an acid is poured upon it, the

water

water which holds the acids in ſolution, contributes to the formation of hepatic gas. As a large quantity of this gas is inſtantly produced, finding no body to retain it in ſolution, it flies off, occaſioning at the ſame time a conſiderable effervescence; ſo that if the experiment be made in a tubulated flaſk, with its tube inſerted into a bell-glaſs filled with water, the elaſtic fluid may be eaſily collected. 2. The ſolution of alkaline ſulphure contains a good deal of gas ready formed; but part of it has been already diſengaged, when the ſulphur was diſſolved; and when an acid is added, the portion of gas which it diſengages is gradually diſſolved in the water; ſo that it produces no ſenſible effervescence, or at leaſt a very inconſiderable effervescence, and no great quantity of gas can be collected.

Sulphurated hydrogenous gas, which is the ſame in all earthy or alkaline ſulphures, and is always an evidence of their exiſtence, has been long known by its fetid ſmell and its action on metals and metallic oxides, eſpecially thoſe of lead and biſmuth, which it very ſoon blackens. Its fetor is quite inſufferable; it is inſtantly fatal to animals; it communicates a green colour to ſyrup of violets, and burns with a light blue flame. If ſet on fire in a large bell-glaſs, very ſuitable for the purpoſe, it clouds the ſides of the veſſel, as it burns, with a depoſite, which is certainly ſulphur. Vital air decompoſes this gas; whenever it comes into contact with atmoſpheric air, there is a portion of ſulphur ſeparated from it. For this reaſon, the ſulphureous waters, mineralized by it, do not contain genuine alkaline ſulphure; though ſulphur be ſeen ſwimming on their ſurfaces,

faces, and found depoſited in the arches or baſons in which they are contained; the waters of Aix-la-Chapelle, Enghien, &c. afford inſtances of this. The ſulphureous depoſites which may be obſerved in flaſks containing ſolutions of alkaline ſulphure, are likewiſe owing to this decompoſition of ſulphurated hydrogenous gas by vital air. Bergman attributes this inſtance of decompoſition to the ſtrong affinity between pure air and phlogiſton. Hepatic gas he conſiders as a combination of ſulphur, phlogiſton, and the matter of heat. When one of theſe principles is ſeparated, the other two can no longer remain in union. M. Gengembre, ſtruck with this phænomenon, that ſulphures neither contain nor exhale ſulphurated hydrogenous gas, except when diſſolved in water, or made up in the humid way, thinks that the fluid may poſſibly contribute to its formation by undergoing a decompoſition,—that while its vital air unites with one part of the ſulphur, its hydrogene, which is at the ſame time diſengaged, diſſolves likewiſe a ſmall portion,—and that this ſolution conſtitutes ſulphurated hydrogenous gas. He imitated the formation of this gas by melting ſulphur above mercury, under a bell-glaſs filled with hydrogenous gas, by the action of the rays of the ſun collected in a lens nine inches in diameter. The ſulphur was partly diſſolved, and communicated to the gas all the characteriſtic properties of hepatic gas. But, as ſulphur by itſelf does not decompoſe water, and as oxigene has a greater affinity with hydrogene than with ſulphur, M. Gengembre thinks that alkali promotes the decompoſition of water by ſulphur, in conſequence of its tendency to unite with the body produced by the combination of

ſulphur

ſulphur with oxigene; that is, with the ſulphuric acid. In ſupport of this theory, M. Gengembre obſerves, that the more power acids have to retain their oxigene, ſo much the more ſulphurated hydrogenous gas do they diſengage from alkaline ſulphures, becauſe the water is then decompoſed rather than the acid. Such, in his opinion, is the reaſon why the muriatic acid affords one half more of this gas than the nitric acid; as has been remarked by Meſſrs Scheele and Sennebier. Laſtly, Scheele's proceſs for obtaining a conſiderable quantity of ſulphurated hydrogenous gas, by diſſolving, in a dilution of the ſulphuric acid in water, an artificial pyrites, conſiſting of three parts of iron and one of ſulphur, ſtrongly confirms this opinion. It appears then, that vital air decompoſes ſulphurated hydrogenous gas, by combining with the hydrogene to form water, while the ſulphur is precipitated.

Water diſſolves ſulphurated hydrogenous gas readily enough; and the ſolution is a perfect imitation of mineral waters.

The earths and the alkaline ſubſtances ſeem to have no power of action on this gas.

The ſulphuric acid does not decompoſe this gas; but the ſulphureous acid detaches it from its ſulphur, becauſe the oxigene of this gas being partly in a free ſtate, unites more readily with the hydrogene of the gas.

The red nitrous acid in which the oxigene is but very feebly retained, acts with great ſtrength in decompoſing this gas, and precipitates the ſulphur. This acid is very happily employed to determine whether ſulphur exiſts in mineral waters.

Alkaline

Alkaline ſulphure decompoſes earthy neutral ſalts as well as ſolutions of metals; as we ſhall hereafter ſee.

Liquid ammoniac has ſcarce any power of acting on concrete ſulphur. Yet Boerhaave aſſerts, that, when that liquor ſtands long over flowers of ſulphur, it tinges them with a golden colour. To make theſe two bodies enter into combination, they muſt be in the ſtate of vapour when they are brought into contact. For this purpoſe, a mixture, conſiſting of equal parts of quick-lime and ammoniacal muriate, and half a part of ſulphur, is ſubmitted to diſtillation. In this proceſs, which muſt be carefully conducted, a reddiſh yellow liquor is obtained, of a pungent and fetid alkaline ſmell; in a word, a genuine ammoniacal ſulphure, which exhales a whitiſh ſmoke when brought into contact with air, from which property it has received the name of *Boyle's fuming liquor*. Heat decompoſes this ammoniacal ſulphure: in a certain ſpace of time, a great many ſmall *iriſed* needles, a line or two in length, are formed in it: they appear to be concrete ammoniacal ſulphure in cryſtals. A thin, blackiſh, and often golden cruſt, is formed on the ſides of the veſſels. Lime and fixed alkali decompoſe the fuming liquor; the acids too precipitate the ſulphur with great facility, and diſengage ſulphurated hydrogenous gas in an highly inflammable ſtate. From theſe decompoſitions there reſult different ammoniacal ſalts, according to the nature of the acid employed. A miſtake which I made in one of my courſes, led me to obſerve a fact which deſerves to be laid before the reader. Wiſhing to precipitate Boyle's fuming liquor, I took up a flaſk ſtanding on

my

my table, and inſcribed *ſpirit of vitriol:* it was almoſt empty, which hindered me from obſerving that what it contained was ſulphuric acid highly concentrated. I poured a few drops of it on ammoniacal ſulphure; a rapid motion was inſtantly excited, a very thick white cloud aroſe out of the veſſel containing the mixture, and it produced a report like that of a great gun; the liquor ſpringing out of the glaſs, was carried to a conſiderable diſtance; the glaſs became very hot, and burſt into pieces; on ſome of its fragments there remained a little ſulphur in a thick yellowiſh magma. I repeated this experiment many times with proper precautions, and ſtill found it attended with the ſame reſult; a violent motion was produced, and the mixture was carried to a diſtance. But theſe ſeveral phænomena ſucceed each other ſo rapidly, that it is impoſſible to avoid confounding them. I have not found the moſt fuming nitrous acid to produce the ſame effects on ammoniacal ſulphure that had been prepared ſome time before. The mixture was violently agitated; a conſiderable degree of heat and ebullition was produced; a white cloud of ammoniacal nitrate iſſued from the veſſel; but there was no exploſion, ſuch as the concentrated ſulphuric acid produces on the ſame hepatic liquor, however long it may have been prepared. M. Prouſt affirms, that when nitrous acid is poured on two drams of Boyle's fuming liquor, it produces as violent a ſhock as two grains of fulminating powder could produce. But this phænomenon does not take place unleſs the ammoniacal ſulphure have been recently prepared.

Ammoniacal

Ammoniacal carbonate likewiſe combines with ſulphur. When theſe two bodies, both in a vaporous ſtate, come into contact, they combine to form a concrete ammoniacal ſulphure. It is obtained by diſtilling a mixture conſiſting of equal parts of carbonate of potaſh or lime, and ammoniacal muriate, together with half a part of ſulphur. This ſulphure is of a brown red colour, and in cryſtals; when diſſolved, it exhales ſome white vapour: heat decompoſes it; air alters it, and deſtroys its colour. It is liable to decompoſition by acids, &c. The ſulphurated hydrogenous gas which it affords, contains carbonic acid. It is to be obſerved, that this concrete ammoniacal ſulphure is nothing but ammoniacal carbonate, contaminated with a little of Boyle's liquor; for it is impoſſible for ammoniac to hold ſulphur in ſolution when combined with the carbonic acid, as this acid readily precipitates the ſulphur of ammoniacal ſulphure.

Several of the acids have a ſtronger or a weaker power of action on ſulphur. If ſulphuric acid be boiled on ſulphur, the acid acquires an amber colour, and a ſulphureous ſmell; the ſulphur melts and ſwims like oil; when cooled, it is formed into concrete globules of a lighter or a deeper green, according as the ſulphur has been for a longer or a ſhorter time in ſolution. A ſmall portion of the ſulphur remains diſſolved in the acid, but may be precipitated, as M. Baumé has ſhown, by means of alkali. This experiment, and ſeveral others of the ſame nature, have led M. Berthollet to think that the ſulphureous is nothing but the ſulphuric acid, holding ſulphur in ſolution. And his opinion actually agrees with all the modern experiments which have

have any relation to this matter; for they concur in ſhowing that the ſulphureous differs from the ſulphuric acid only by containing a greater proportion of ſulphur.

The flaming red nitrous acid acts powerfully on ſulphur. M. Prouſt firſt obſerved, that when red nitrous acid is poured on melted ſulphur, it occaſions detonation and inflammation. M. Chaptal has made a ſeries of experiments on this matter. By diſtilling nitrous acid on ſulphur, he diſſolved it ſo as to produce ſulphuric acid: and it appears therefore, that oxigene has a greater affinity with ſulphur than with azote or nitrogene.

The common muriatic acid effects no alteration on this combuſtible body; but the oxigenated muriatic acid acts upon it with more energy. But our experimental knowledge of this fact is ſo imperfect that it is unneceſſary to inſiſt longer upon it here.

Sulphuric neutral ſalts are incapable of acting on ſulphur; but nitric ſalts cauſe it to burn rapidly, even in cloſe veſſels. The theory of this important phænomenon is very ſimple. Nitre decompoſed by heat affords a very conſiderable quantity of vital air: ſulphur is a very combuſtible ſubſtance, or, which is the ſame thing, has a ſtrong tendency to combine with oxigene; nitre affords the principle neceſſary to its combuſtion; ſo that the atmoſpheric air is no longer requiſite to make it flame. The products obtained by this operation are very different, according as the nitre and the ſulphur are employed in different proportions. If a mixture conſiſting of eight parts of ſulphur and one of nitre be ſet on fire in a cloſe veſſel, the ſulphur burns with

with a very lively white flame, and is converted into ſulphuric acid. This method has been uſed for theſe twenty years in England and Holland for preparing this acid, which was formerly obtained from *vitriol*. In England, large glaſs balloons, with very large necks, holding each four or five hundred pints, were the veſſels firſt uſed in making this preparation. A number of theſe were arranged together on a bed of ſand; they were diſpoſed in two lines at a proper diſtance from each other, ſo that a perſon might conveniently go and come between them: a few pounds of water were put in each of the veſſels, and a ſtone pot was introduced into the neck of each, having upon it a red-hot ladle of caſt iron with a long handle. Into this ladle, by means of another ladle of white iron, there was put a mixture of ſulphur and nitre in due proportions: after which the apperture of the balloon was ſtopped with a piece of wood. The heat of the ladle kindled the mixture; the ſulphur was burnt by the vital air of the nitre; and after the combuſtion was effected, the ladle was taken out, and the vapours ſuffered to condenſe. The ſame operation was repeated on all the balloons of the two rows; ſo that when the operator returned to the firſt balloon, he found the vapours entirely condenſed, and might proceed to burn in it a new quantity of the mixture. When the water was ſufficiently ſaturated with the acid, it was poured out into glaſs retorts: the water was then ſeparated by diſtillation, and the acid concentrated, till a phial containing an ounce of diſtilled water would receive a quantity of it weighing one ounce ſeven drams and an half. Such was the Engliſh proceſs for preparing *oil*

of

of vitriol, or concentrated ſulphuric acid. But it was attended with great expence, on account of the high price and the brittleneſs of the balloons. A few years ago, there was a method contrived of burning ſulphur on a ſort of gridirons in large apartments lined all over with lead; the ſulphuric acid, as it condenſed, is conveyed by gutters into a reſervoir, and afterwards concentrated by the action of fire. This is the proceſs uſed in the manufactory of Javelle near Paris; the eſtabliſhment of which cannot but be of advantage to the arts. It is of conſequence to obſerve, that the ſulphuric acid thus obtained is always in union with a little ſulphur and ſulphate of potaſh; it is likewiſe found to contain a little aluminous ſulphate and ſome ſulphate of lead. But theſe ſubſtances are mixed with it in ſo inconſiderable a proportion, that their effects are of no conſequence in moſt of the occaſions on which this ſaline matter is employed: beſides, it may be eaſily purified, by diſtilling it to dryneſs, ſo as to be ſuitable enough even for the niceſt chemical experiments.

If inſtead of an eighth part of nitre, we burn equal parts of ſulphur and of nitre; then, inſtead of ſulphuric acid in a free ſtate, the product obtained is ſulphate of potaſh, formed by the combination of that acid with the fixed alkaline baſe of nitre. Salt obtained in this manner was called *Glaſer's polychreſt ſalt*. It was prepared by caſting into a red-hot crucible, a mixture conſiſting of equal parts of ſulphur and nitre. The reſidue was diſſolved in water, and the ſolution evaporated to a pellicle; it was then filtered, and afforded by cooling cryſtals of genuine ſulphate of potaſh; which re-

ceived their particular denomination, becauſe Glaſer was the firſt who made known this mode of preparation: but the ſalt thus obtained differs in no reſpect from common ſulphate of potaſh.

Gun-powder, the terrible effects of which are owing to its ſtrong tendency to combuſtion, is a mixture of ſulphur and nitre with charcoal. Moſt part of it is nitre; the proportion of charcoal is much ſmaller; and it contains but a very trifling quantity of ſulphur. An hundred pounds of gun-powder from Eſſone near Corbeil, contain ſeventy five pounds of nitre, nine and an half of ſulphur, and fifteen of charcoal. This mixture is triturated for ten or twelve hours in wooden mortars, with peſtles of the ſame ſubſtance; a very ſmall portion of water is from time to time poured upon it. When the fluid is almoſt wholly evaporated by the trituration, ſo that the powder may be put on a ſtone-plate without wetting it, it is then taken away to be granulated. The granulation of powder is accompliſhed by paſſing it thro' ſeveral ſkin-ſieves, which are moved backwards and forwards in a ſtraight line. The holes of theſe ſieves are of various ſizes, the ſmalleſt being thoſe which form grains of gun-powder. The granulated powder is next ſifted to ſeparate the duſt: it is then carried to the houſe for drying it; which is a ſhed expoſed to the ſouth, and receiving the rays of the ſun through glaſs windows. Cannon powder receives no farther preparation. Muſket powder is glazed, that it may not ſoil the hands. To perform this operation, a caſk with a ſquare axis paſſing through it, which communicates with a water wheel, is half filled with powder. The motion of the

caſk

caſk occaſions a continued friction, by which the grains of the powder are worn ſmooth. The powder thus glazed, is paſſed through a ſieve to ſeparate the duſt; and afterwards through another ſieve, which divides the grains into two kinds of muſket-powder, a finer and a coarſer. M. Baumé, in conjunction with the Chevalier d'Arcy, has made a ſeries of laborious experiments on the preparation of powder, on the different degrees of the force of this compound ſubſtance, according as its ingredients are mixed in different proportions, and on its analyſis. In the courſe of theſe, the gentlemen have made a variety of diſcoveries, of which we ſhall here mention only the moſt important, and ſuch as have a more immediate connection with the theory of chemiſtry. 1. No good powder can be made without ſulphur, though this mode of preparing it has been attempted by ſeveral people: ſulphur increaſes its ſtrength amazingly. 2. All coals, whether light or ponderous, except ſuch as are formed by the combuſtion of animal matters, are equally proper for this compoſition. 3. Coal is one of the moſt eſſential parts of powder; for a mixture of ſulphur and nitre is far from producing the ſame effects as when coal is added. 4. The goodneſs of powder depends entirely on the ſubſtances of which it is compoſed being duly proportioned; and the trituration being continued till the matter riſe in duſt all around the mortar. 5. The effects of powder are much more powerful when it is ſimply dried than when it is granulated. The moiſture neceſſary to make powder aſſume a granulated form cryſtallizes the nitre, which is then ſeparated from the other ſubſtances; and it may be perceived in the inte-

rior part of the grains, if they be cut aſunder, and examined through a magnifier. 6. Glazed or muſket-powder has leſs ſtrength than cannon-powder, which has not undergone the ſame operation; becauſe the particles of the former are more cloſely united, and of conſequence not ſo inflammable.

As to the analyſis of powder, M. Baumé effected that in a very ſimple way. His proceſs conſiſts in waſhing cannon-powder, after it has been ſufficiently pulverized, with diſtilled water, and evaporating the water: by this firſt operation the nitre is obtained; the reſidue is the charcoal and the ſulphur. The ſulphur ſeems to be in part fixed by the coal, ſo that it cannot be entirely ſeparated by ſublimation. M. Baumé employed a faint heat, capable of burning ſulphur but not charcoal. The charcoal, however, always retains a little ſulphur; for as that chemiſt has obſerved, it exhales a ſulphureous ſmell till it be entirely reduced to aſhes. He eſtimates the ſulphur retained by the charcoal at one twenty-fourth part of the total weight. The powder may likewiſe be diſſolved, by expoſing it entire and unwaſhen to the action of a moderate fire. This fact was known to Mr Robins, who gives an account in his Treatiſe on Gunnery, written in Engliſh. Poachers are ſaid to be in the practice of depriving powder of its ſulphur by heating it on warm aſhes in a tin plate. They are perſuaded from experience, that powder thus deprived of its ſulphur, expels the ſhot to a farther diſtance, and is leaſt injurious to the fire-arms.

Chemiſts and natural philoſophers have entertained various opinions concerning the violent effects of gun-

powder.

powder. Some have attributed them to the reduction of the water to vapour; others to the ſudden dilation of the air. M. Baumé thinks that they are owing to the formation of nitrous ſulphur at the moment of combuſtion. In my opinion this phænomenon may be very eaſily explained, with the help of the modern diſcoveries. In order to underſtand my theory, the reader muſt firſt take notice, that whatever paſſes during the inflammation of powder is owing to its extreme combuſtibility. But both ſulphur and charcoal, when they have undergone a conſiderable comminution, are very inflammable bodies. The intimate mixture which has ſuch an influence on the ſtrength of powder, according to the valuable experiments of M. Baumé, is the ſole cauſe of the effects which it produces. The nitre is equally diſtributed through all the integrant parts of theſe extremely combuſtible bodies. As the quantity of the nitre is much more conſiderable than that of either of them, each particle of the ſulphur and the charcoal is incloſed, and as it were incruſted in nitre. Each of the two combuſtible bodies has of conſequence much more vital air than is requiſite to make it burn completely; for it has been ſhown that nitre, when acted upon by heat, gives out a conſiderable quantity of that fluid. The ſame thing happens therefore in this caſe as when a combuſtible body is immerſed into a veſſel filled with vital air. On ſuch an occaſion it is known, that the body ſcintillates while it burns, and is much ſooner conſumed than it would have been in atmoſpheric air. From this we can eaſily conceive the cauſe of the rapid inflammation of gun-powder; why it takes place in cloſe veſſels as well as in the open air; and why, when

any obſtacle is oppoſed to ſo terrible an agent, it produces ſuch exploſions, and expels the obſtacle with ſuch violence.

The effects of this mixture of nitre, ſulphur, and charcoal, are nothing in compariſon with thoſe produced by another mixture called *fulminating powder*. That powder is made up of three ounces of nitre, two of carbonate of potaſh, or *fixed ſalt of tartar, very dry*, and one of powdered ſulphur. This mixture is triturated in a hot marble mortar with a wooden peſtle, till the three matters be fully mixed. A dram of this powder expoſed to a moderate heat in an iron ladle, melts, and in a ſhort time produces a detonation as loud as the report of a cannon. To underſtand the cauſe of this phænomenon, which is the more aſtoniſhing, becauſe fulminating powder does not need to be incloſed and preſſed together like gun-powder, in order that it may produce it, we muſt obſerve, 1. That it does not take place, except when the mixture is ſlowly heated, till it become liquid. 2. That when fulminating powder is caſt on burning coals, it only melts like nitre, without noiſe. 3. That a mixture of ſulphure of potaſh with nitre, in the proportion of one part of the firſt ſubſtance to two of the ſecond, fulminates more rapidly, and with as much noiſe as that which is made up of ſulphur, nitre, and alkali. It appears therefore, that when fulminating powder is heated, it produces ſulphure of potaſh before detonizing. This fact alone explains the phænomenon which we are conſidering. When nitre in cryſtals and ſulphure of potaſh are expoſed to the action of heat, ſulphurated hydrogenous gas is diſengaged from the ſulphure, and vi-

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tal air from the ſalt. Theſe two gaſes, which, as we have ſeen in the hiſtory of hydrogenous gas, are capable of producing a ſmart detonation, are inflamed by a part of the ſulphur which kindles of itſelf. But as the thick fluid through which they muſt paſs oppoſes an obſtacle to their inflammation, and as they kindle on all ſides at once, they ſtrike the air with ſuch rapidity in their combuſtion, that it reſiſts them in the ſame manner as the ſides of fire-arms reſiſts gun-powder. This reſiſtance appears evidently from the effects which fulminating powder produces on the ladle in which it is expoſed to the fire; the bottom of that veſſel is pierced through, or bulged outwards, and its ſides are bent inwards, as if it had been expoſed to the action of a force directed perpendicularly downwards, and of another acting laterally.

The laſt mixture of nitre and ſulphur which we have to conſider, is called *powder of fuſion*. It is made up of three parts of nitre, one of ſulphur, and one of ſaw-duſt. A little of this powder is put into a nut-ſhell, with a bit of copper rolled together; fire is then ſet to it; it kindles and burns with rapidity, melting the piece of copper, which is afterwards found in that ſtate in the bottom of the ſhell; though the ſhell is only blackened, not burnt. But it is neceſſary to immerſe it in water as ſoon as the powder ceaſes burning. This experiment proves the powder employed in it to be a very fuſible matter. But as it is moſtly owing to the action of the ſulphur on the metal, we will take more particular notice of it in the hiſtory of metallic matters.

The muriatic, the fluoric, and the boracic neutral ſalts, have no power of action on ſulphur. We have ſeen, that the alkaline carbonates unite with this ſubſtance, and render it ſoluble in water, by forming alkaline ſulphures which are not cauſtic.

Hydrogenous gas does not act in a determinate manner on ſulphur. Formerly, it was quite natural to find a ſtrong analogy between theſe two bodies; for when ſulphuric acid diluted in water is combined with combuſtible matters, it produces hydrogenous gas; and if it be concentrated, it affords ſulphur. Sulphur is likewiſe formed in large maſſes of putrefying animal matters. When combined with alkaline matters, ſulphur appears to ſuffer an alteration of nature, paſſing into the ſtate of ſulphurated or *hepatic* hydrogenous gas. Laſtly, Hydrogenous gas acts on a great many bodies, nearly in the ſame way as ſulphur. We might ſtill think, therefore, that theſe two bodies were in ſome meaſure the ſame, were it not fully demonſtrated, that hydrogenous gas is almoſt always produced by the decompoſition of water, and equally certain that ſulphur is never a principle of that ſubſtance.

Sulphur is capable of combining with many other ſubſtances; but as we are ſtill unacquainted with thoſe ſubſtances, we will defer giving an account of their union with this mineral, till we come to deſcribe their properties.

Sulphur is an excellent medicine for pituitous diſeaſes of the lungs, and ſtill more ſo for cutaneous diſorders. It is ſucceſſfully adminiſtered in the caſe of the humid aſthma, and in ſcorbutic eruptions, &c. It is given either in flowers or in lozenges made up with ſugar.

gar. It is mixed with fats into an ointment for rubbing ſuch parts of the body as are affected with the itch. Alkaline ſulphures have been propoſed as remedies for obſtructions, numbneſs, palſies, cutaneous diſorders, &c. Some phyſicians have ſuppoſed, that ſulphur is not diſſolved in animal humours; yet it is certain that it penetrates to the extremities of the moſt minute veſſels; for the breath, the urine, and the ſaliva of perſons, who make uſe of ſulphur, are impregnated with it. Sulphurated hydrogenous gas diſſolved in mineral waters, as in thoſe of Cauterets, Aix-la Chapelle, Barege, Enghien, &c. communicates to them inciſive qualities, which render them very ſerviceable in diſorders of the ſkin, lungs, and joints, and in palſies, &c.

Sulphur is no leſs uſeful in the arts. It is one of the moſt neceſſary ingredients of gun-powder. It is uſed in taking the fineſt impreſſions of engravings on ſtone; it is made into combuſtible matches; it is burnt to whiten ſilks, to deſtroy certain colours, and to put a ſtop to the fermentation of wines, &c. It has been propoſed for fixing iron in ſtones, &c.

CHAP.

CHAP. IV.

Genus IV. *Metallic Subſtances in general.*

METALLIC ſubſtances are a very important and uſeful order of natural bodies, in their application to the purpoſes of common life, in chemiſtry, and in medicine. They are eſſentially different from ſaline and earthy matters, both in their phyſical characteriſtics and in their chemical properties.

Before entering upon a particular examination of each of theſe ſubſtances, it will be proper to conſider them in general. In doing this, we ſhall treat, 1. Of their phyſical properties. 2. Of their natural hiſtory. 3. Of the art of aſſaying them, or determining their nature and quantity. 4. Of metallurgy, or the art of working them in the great way. 5. Of their chemical properties

properties. 6. Of the means of diſtinguiſhing them from one another, and of the diſtinctions neceſſary to be made among them.

§ I. *Of the Phyſical Properties of Metallic Subſtances.*

METALLIC ſubſtances are abſolutely opaque; much more ſo than ſtones; for a very thin plate, even of the moſt opaque ſtone, is in ſome degree tranſparent; whereas the thinneſt plate that can be formed of any metal is equally opaque with the largeſt maſs. The opacity of metallic ſubſtances renders them peculiarly ſuitable for reflecting the rays of light: no body poſſeſſes this property in ſo eminent a degree as they; glaſs mirrors muſt be coated with metal in order that they may reflect objects. This property peculiar to metals is the cauſe of their luſtre or brilliancy; a quality which is always in the compound ratio of the denſity or hardneſs of any metal which enables it to receive a fine poliſh, and of its colour. White metallic ſubſtances reflect more rays, and are more brilliant than thoſe which are coloured.

The ſpecific gravity of metallic ſubſtances is much more conſiderable than that of other mineral bodies. A cubic foot of marble weighs but two hundred and

fifty

fifty-two pounds; a cubic foot of tin, which is the lighteſt of all metals, weighs five hundred and ſixteen pounds. This ſuperior gravity of metals, which ſo much exceeds that of earthy matters, depends no doubt on their extraordinary denſity, to which they owe likewiſe their luſtre and opacity.

Moſt metallic ſubſtances may be dilated by repeated percuſſion, or by ſtrong preſſure. This property, which is peculiar to theſe ſubſtances, and of which we have not before had occaſion to take notice in any of the matters which we have hitherto been examining, bears the name of *Ductility*. It may be diſtinguiſhed into two kinds: the one, ductility under the hammer, or *malleability*, makes thoſe metals to which it belongs to admit of being beaten out into thin plates without breaking: lead and tin are metals poſſeſſing this kind of ductility. The other is the continued and almoſt extreme prolongation of metallic matters, ſo as to form them into threads of more or leſs fineneſs: this is the ductility of wire, of which iron, copper, and gold are ſuſceptible. It is likewiſe called *tenacity*. It is of the more conſequence to diſtinguiſh accurately between theſe two ſpecies of ductility, becauſe they appear to be really very different from each other; for metallic ſubſtances which are very malleable often have ſcarce any tenacity; while others, which have much of the ductility of wire, are ſcarcely malleable. The tenacity of metals may be very accurately expreſſed by mentioning the weight which a wire of any metal of a known diameter is capable of ſuſtaining without breaking. Both of theſe properties ſeem to depend on the particular form of the integrant parts of the various metals to which they belong.

long. Metals which admit of being beat out into thin plates, ſeem to conſiſt of ſmall laminæ, which, when compreſſed, are removed from a vertical to a lateral direction in regard to each other, ſo that the ſuperficies of the maſs is encreaſed while its thickneſs is diminiſhed. Thoſe again which are ſuſceptible of being ſpun into wire, ſeem to have a fibrous contexture: their fibres being diſpoſed in collateral bundles, unite and eke out one another, when expoſed to that violent preſſure which forms them into wire.

But the ductility of metals goes only to a certain length. When any metal, however ductile, has been repeatedly beaten with an hammer, it becomes hard and brittle, and its length can be no farther extended. This property is named *induration*. When an indurated metal is ſlowly heated with proper precautions, it regains its ductility, and may be again ſtruck with the hammer without danger of breaking. It appears that the parts of any metal are lengthened out under the hammer only in proportion as they find ſpace, which they may occupy when they flee the preſſure to which they are expoſed. And it may be eaſily underſtood, that when thoſe parts have been once ſo cloſely compreſſed by percuſſion that ſcarce any interſtices remain between them, they can no longer eſcape from under the hammer, and the metal muſt therefore break into pieces. Heat, by dilating the metal, again ſeparates its parts, and produces new ſpaces between them, which afford them room to unite more cloſely in conſequence of repeated percuſſion.

As ſome metallic ſubſtances are not at all ductile, chemiſts and naturaliſts have diſtinguiſhed metals into claſſes,

claſſes, according as they poſſeſs or want this property. They give the name of *metals* to thoſe ſubſtances in which the properties of ductility, opacity, gravity, and metallic brilliancy are united; and they call thoſe *ſemi-metals*, which, though apparently metallic, are deſtitute of ductility. But this diſtinction, though accurate enough, is inſufficient to divide all metallic matters into two claſſes; for, from the amazing ductility of gold to the ſingular brittleneſs of arſenic, we find all metals poſſeſſed of this property,—varying in them indeed by inſenſible degrees: and the difference between the ductility of gold and that of lead is perhaps ſtill more conſiderable than that which ſubſiſts in this reſpect between Lead and zinc which is reckoned a ſemi-metal, or between zinc and arſenic. Beſides, the word *ſemi-metal* is expreſſive of a very hypothetical opinion concerning the nature and formation of metals.

Metals, conſidered with reſpect to their ductility, may be arranged in the following order. Gold is the moſt malleable of all metals: ſilver, copper, iron, tin, and lead, follow in the order in which they are here expreſſed. The ſemi-metals have been conſidered as deſtitute of ductility. We ſhall ſee, however, that mercury and zinc poſſeſs this property in a certain degree. As to tenacity, gold poſſeſſes this property likewiſe in the moſt eminent degree; next follow iron, copper, ſilver, tin, and lead. We know not well in what degree platina poſſeſſes this property.

Metallic ſubſtances are ſuſceptible of a regular form, which is ſometimes conferred on them by the hand of nature; and they readily receive it from art. Naturaliſts have long been acquainted with this property of

metals;

metals; native biſmuth, virgin ſilver, with ſome other metals, are of a regular form in their natural ſtate. Even the alchemiſts painfully obſerved the ramified or ſtellate figures on the ſurface of antimony and biſmuth. M. Baumé, in his rational and experimental chemiſtry, informs us, that metallic matters, after being melted, aſſume, if ſlowly cooled, a regular ſymmetrical arrangement. The Abbé Mongèz, who accompanied M. de la Peyrouſe on his voyage round the world, has made a ſeries of enquiries and experiments on the cryſtallization of metallic matters. M. Brongniart, lecturer on chemiſtry in the King's garden, has alſo turned his attention to this object; and many other chemiſts have repeated their experiments. The general reſult is, that all metals are ſuſceptible of cryſtallization; and though the cryſtalline form of ſome among them may appear different, moſt of them exhibit the ſame octohædral form, with ſome variety of modifications.

Some metallic matters have both taſte and ſmell; ſuch as arſenic, antimony, lead, copper, tin, and iron. Theſe properties are invariably met with in all the metals that are the moſt liable to alteration; ſometimes even in ſo eminent a degree, that they corrode and entirely deſtroy the organs of animals.

§ II. *The Natural Hiſtory of Metallic Subſtances.*

METALLIC ſubſtances exiſt in the interior parts of the earth in four different ſtates. In the firſt, the metal is virgin or native; that is, poſſeſſed of all its properties. Gold is always found in this ſtate; ſilver, copper, mercury, biſmuth, and arſenic, are often found in their native beds in a ſtate of equal purity: Nature ſeldom preſents us with iron, and ſtill ſeldomer with lead, zinc, antimony, &c. in this ſtate.

The ſecond ſtate in which metallic ſubſtances are found is that of *calces*, or oxides; in which ſtate they have not the appearance of metals, but rather reſemble ochres or earthy matters. Copper is often found in the ſtate of a green or blue oxide; iron in a yellow, red, or brown oxide; lead in a white, grey, yellow, or reddiſh oxide; zinc in the ſtate of calamine; cobalt in red flowers; arſenic in a white oxide, &c.

The third ſtate natural to metals, that in which they are commonly found, is in ores. In this ſtate the metallic ſubſtance is combined with a combuſtible matter, which renders it incapable of exerting its properties till it be ſeparated from this matter. This matter, which is called the *mineralizer*, is either ſulphur or ſome other metal. Some chemiſts aſſert, that ſulphur is the moſt common mineralizer. It is united with ſilver in vitreous ſilver ore. Copper ores always contain a very large proportion of ſulphur. Iron is combined with this

this ſubſtance in the martial pyrites; lead in the galena; mercury in cinnabar; zinc in blend; laſtly, biſmuth is ſometimes, and arſenic often, found in union with ſulphur.

It is proper to obſerve, that all metals have not the ſame affinity with ſulphur. Some of them contain a great quantity, and are eaſily deprived of it. Their metallic luſtre is but little altered by it. Copper, lead, and antimony are of this character. Others again contain but a ſmall portion of ſulphur; but that ſo intimately united with them as to deſtroy all their metallic properties: cinnabar affords an inſtance of this fact.

One metal is ſometimes in union with another; but arſenic is the great mineralizer. Iron, tin, and cobalt are often found in union with arſenic; ſometimes a metal is united with both ſulphur and arſenic at the ſame time; as for inſtance, in the red ore of antimony, and in red ſilver. Laſtly, there are ſome metallic ores which conſiſt of ſeveral metals, with ſeveral mineralizing ſubſtances, ſuch as grey copper ore, grey ſilver ore, and ſome others.

The fourth ſtate in which metals are found in the bowels of the earth is in combination with acid ſaline ſubſtances. The ſulphuric acid is often found in combination with metals; the oxides of zinc, lead, copper, and iron, are generally in the ſtate of ſulphates; the carbonic acid is one of the common mineralizers of metals: the muriatic, the arſenic, and the phoſphoric acids have been within theſe few years proved to contribute at times to the ſame end.

Metallic ſubſtances are not nearly ſo copious as ſtony matters in the terreſtrial globe. The ſtate in which mineralized metals are moſt commonly found is in veins obliquely interſecting the ſtrata of earths and ſtones of which mountains are compoſed. Metals in the ſtate of oxides or ſalts are often found in maſſes, which have been carried down, and ſometimes cryſtallized, by water. Some metallic ores are found in ſhapeleſs lumps; theſe owe their formation to ſome ſingular accidents.

Veins of metal run between ſtony matters, which ſeem to have been formed at the ſame period. Theſe are generally quartz and ſpar, and form two ſtrata: the one lying beneath the vein of ore is called *the bed*, or *floor* of the mine; the other, which covers it above, is called its *roof*. Theſe ſtones conſtitute what is called the *gangue*, or *matrix of the mine*, which muſt not be confounded with the mineralizer; for the mineralizer is ſo intimately united with the metal, that it cannot be ſeparated from it otherwiſe than by a chemical proceſs; whereas the gangue may be ſeparated by a mechanical operation. The gangue conſiſts of cryſtallized ſtones; and is therefore to be diſtinguiſhed from the rock which forms the maſs of the hill through which the mine runs. Veins of metal are divided into *rich* or *poor*, *large* or *ſmall*, *ſtraight* or *crooked*.

Metallic ores appear to owe their formation entirely to water. Moſt of them are in cryſtals, or mixed with ſubſtances which would have ſuffered an alteration of nature, if they had been expoſed to the action of fire, ſuch as calcareous ſtones and ſulphur. We find likewiſe among them bodies which ſtill exhibit a vegetable

or

or animal organization, which would alſo have been deſtroyed, had it been expoſed to the action of fire. There are perhaps ſome ores which owe their formation to fire; ſuch as the ſpecular iron ore of Mont d'Or in Auvergne, or that of the iſle of Elba. But ſuch inſtances are rare.

Mines are more generally found in hills than in plains, and almoſt always in hills forming a continued range. It is obſerved, that plants growing on hills which contain metallic matters are never luxuriant, but dry and dwarfiſh: trees in ſuch a ſituation are crooked and ill ſhaped: ſnow melts there almoſt as ſoon as it falls; and the ſand is metal-coloured. Springs of metallic mineral-water are found in the neighbourhood. By examining the waters of theſe ſprings, and the ſand over which they flow, it may be determined with a good deal of certainty whether they communicate with veins of metallic matters. When veins of metal appear near the ſurface, ſuch an indication may be conſidered as a good reaſon for piercing the ground to a greater depth. The boring inſtrument brings up ſpecimens of the ſubſtances which compoſe the interior part of the mountain, and of the metallic mineral matter which it contains; thereby ſhowing the nature of that matter, as well as the reſiſtance which muſt be overcome in order to penetrate to it.

§ III. *Of the Art of Aſſaying Ores, or Docimaſia.*

WHEN a certain quantity of ore is obtained, it is next to be aſſayed, in order that its nature may be exactly determined. This aſſaying of ores is one of the moſt important branches of chemiſtry, and is known by the name of *docimaſia*. Every different ore muſt be aſſayed in a particular manner: yet there are certain general operations common to all proceſſes of aſſaying.

Specimens of the ore are firſt ſelected from among the richeſt, the pooreſt, and thoſe of a middle nature between the two. This ſelection is abſolutely neceſſary; for if only a rich ſpecimen were aſſayed, too flattering hopes might be excited; were the ſpecimen aſſayed from the pooreſt, the reſult might be too diſcouraging. The ſpecimens thus ſelected are piled one above another, and well waſhed with water. The fluid carries off the gangue in powder, while the more ponderous mineral remains in the bottom of the veſſel. The ore thus waſhed muſt next be roaſted with due care, in order that as much as poſſible of the mineralizer may be carried off by ſublimation: the mineral when ſubjected to this operation muſt be incloſed in a ſmall earthen pot covered over with another. This is a neceſſary precaution, as ſome ores burſt into pieces when expoſed to the action of fire, and fly out of the veſſel if it be left open; and ſuch an accident would render the reſult quite uncertain. When this roaſting

is

performed in the open air, it generally reduces the metal to an oxide; and if it be of a volatile nature, even drives off a part of it; and therefore we would rather adviſe the roaſting of ore in a ſtone retort. This proceſs is indeed more tedious and difficult; but it diſcovers the nature and quantity of the mineralizer, and affords a much more accurate analyſis of the mineral under examination. When an ore has been kept red-hot, till it ceaſe to exhale vapours, the roaſting is then finiſhed. The ore was weighed before and after being waſhed, in order that the quantity of its gangue might be exactly determined; and it is to be again weighed after the roaſting, in order that it may be known how much it has loſt by the operation.

After being roaſted, the ore muſt next be melted. For this purpoſe, it is mixed with three parts of black flux and a little decrepitated muriate of ſoda: the mixture is put into a crucible, which is covered cloſe with a lid, and placed in a good fuſing furnace. The alkali of the black flux melts the metal, and abſorbs any part of the mineralizer which ſtill may remain in the ore. The coal of the tartar which is found in the black flux ſerves to reduce the oxide of the metal, by abſorbing its oxigene. The muriate of ſoda hinders the mixture from ſuffering any loſs while in fuſion; becauſe being, when melted, lighter than any of the other matters, it alway occupies the upper part of the crucible, covers the mixture, and is the only one of the ſubſtances of which any part is loſt.

When the fuſion is finiſhed, the contents of the crucible muſt be permitted to cool ſlowly. The matter may be inferred to have been completely melted, if the

metal be united in one lump, the ſuperior ſurface of that lump being of a convex form; if no grains of it appear intermixed with the ſcoriæ; and if the ſcoriæ be united in one compact, uniform, vitreous maſs, covered over with a cruſt of melted marine ſalt. The lump of metal is to be carefully weighed, and the proportion in which the metal exiſts in the ore is then diſcovered.

But ſome ores are harder and more refractory. Fluxes of a more active nature, and thoſe in greater quantity, muſt then be employed; ſuch as borax, pounded glaſs, fixed alkali, &c. The ſame mineral often contains an intermixture of perfect and imperfect metals. Theſe may be ſeparated by heating the lump of metal in the air. The imperfect metal is converted to an oxide, and carried off, leaving the perfect metal in a ſtate of purity. This operation bears the general name of refining. The perfect metal obtained by this proceſs is almoſt always a mixture of gold and ſilver. Theſe two metals are ſeparated by a ſolvent which acts on the ſilver, leaving the gold uninjured: this operation is called *parting* them. The reſidues of all theſe proceſſes ſhould be weighed in the aſſay-balance.

Accurate as this ſeries of proceſſes may appear, it is often of leſs utility than one leſs nicely conducted; for where works of this kind are conducted on a great ſcale, cheaper materials are uſed, and leſs caution is obſerved. Ore is then to be aſſayed by melting it on coals in a fuſing furnace. The coals reduce the metallic oxide; and the fixed alkali, which is produced as they burn, abſorbs part of the mineralizer. It is ſometimes found neceſſary to add a ſmall quantity of

filings

filings or ſcoriæ of iron, in order to facilitate the fuſion of very refractory ores.

There is a method of aſſaying metals in the humid way, which may be employed to diſcover what metals are contained in pieces of ore meant to be laid up in collections of the objects of natural hiſtory. A ſmall bit, broken off from the piece of ore, is digeſted among acids, which diſſolve the metal, and ſeparate the mineralizer. The ſalt produced by the union of the metal with the acid ſhows the quality of the metal. But as all metals are not ſubject to the action of acids, only certain ores can be aſſayed in this manner. Bergman has written an excellent diſſertation on the aſſaying of metals in the humid way, which the reader may conſult with advantage.

§ IV. *Of the Art of Extracting and Purifying Metals in the great way, or of Metallurgy.*

WHEN it appears from a particular aſſay, that the working of a mine is likely to be profitable, the following train of operations are then to be employed for the purpoſe. A perpendicular ſquare pit is dug in the ground, large enough to admit ſtraight ladders on which the workmen may go down and come up. An axis is uſually placed over the mouth of the pit,

for the purpoſe of raiſing up buckets filled with the mineral; pumps too are ſometimes put into it for carrying off the water. If the mine be ſo deep that one perpendicular pit cannot be carried down ſo far as to reach the floor of the ore, an horizontal drift is formed, at the end of which a new ſhaft is ſunk, and this is done repeatedly, till the laſt ſhaft penetrate to the bottom of the mine.

If the rock through which the works are carried be ſo hard and firm as to be in no danger of falling down, there will then be no occaſion for propping it with any artificial ſupport. But if they be cut through ſoft ſtone, or earth likely to crumble down; it will then be neceſſary to prop the galleries or drifts, and to line the ſhafts with planks.

It is an object of conſequence to procure regular ſupplies of freſh air in mines. Where it is practicable to open a paſſage from the bottom of a ſhaft, which may communicate with the plane below, a current of air is eaſily produced. Where this cannot be effected, a new ſhaft is ſunk at that part of the gallery which is moſt diſtant from the former ſhaft. When one of theſe two ſhafts is higher than the other, the air eaſily circulates; but if they be equally high, a current of air cannot be produced. When the laſt is the caſe, a fire is kindled in a furnace over the mouth of one of the ſhafts, and ſufficient ſupplies of freſh air are thus conveyed regularly into the gallery.

Water is very troubleſome in mines. If it flow ſlowly through the earth, it is then conducted in a channel along the floor of the mine, and conveyed by a ſloping drift into the next river. If it riſe in greater abundance

dance it is carried off by pumps. Sometimes when a rock is cut, a quantity of water burſts out, ſufficient to fill all the galleries in an inſtant. The reſounding of the rock when it is ſtruck, warns the workmen before this event take place; and they prepare for it by forming a door in one of the galleries; one of the miners cuts the rock to give vent to the water, and inſtantly retires, ſhutting the door, which hinders the water from overtaking him.

Vapours conſiſting of carbonic acid and hydrogenous gas iſſue from mines, and are either diſengaged or formed by the mutual re-action of the mineral and metallic matters. The fires which are neceſſary to ſoften the rock, generally contribute to the diſengagement of thoſe gaſeous ſubſtances; the dangerous effects of which cannot be otherwiſe prevented, but by rapid currents of air, or by detonation.

When the mineral is dug and brought out of the earth, it is then pounded, waſhed, roaſted, melted, and refined. It is pounded by large knockers moved by water; theſe are called (in French) *bocards*. When it is pounded, it is put on inclined tables to be waſhed, in order that the water may run off, and carry with it the gangue. Ores containing much ſulphur ſhould be roaſted in the open air; thoſe which contain but a little ſulphur may be roaſted in the furnaces in which they are to be afterwards melted. Some ores melt by themſelves; others require fluxes to diſpoſe them to fuſion, and muſt likewiſe be put into contact with charcoal. Furnaces for fuſion are of various kinds, according to the country and quality of the ore. Furnaces for refining are conſtructed nearly

nearly in the ſame manner as the others. Sometimes the ſame furnace ſerves for both operations. When metals are thus reduced, there are almoſt always ſeveral of them intermixed together. They muſt then be ſeparated by proceſſes entirely of a chemical nature, which ſhall be deſcribed when we treat ſeparately of the different metals.

§ V. *Of the Chemical Properties of Metallic Subſtances.*

ALL the chemical properties of metallic ſubſtances concur to repreſent them as ſimple matters, not liable to decompoſition. The alterations which they ſuffer from heat, air, and ſaline ſubſtances, are always owing to combination; not one of thoſe alterations can with any reaſon be compared to an analyſis, as we are about to ſhow by a particular account of the phænomena which they exhibit on ſuch occaſions.

Light appears to alter the colour and luſtre of ſome metallic ſubſtances. Some metals, when incloſed in tranſparent veſſels, are ſullied, and acquire gradually a new colour, which deprives them of their brilliancy. This kind of alteration has not been obſerved.

Heat effects ſome changes on the aggregation of metals, with various degrees of quickneſs and facility. All metallic ſubſtances are liable to melt on being heated in cloſe veſſels; ſome of them long before becoming

coming red-hot, others at the very inſtant when they become red, and others not till a conſiderable time after. There are as many different degrees of the fuſibility of metals as there are different kinds of metals. If left to cool after melting, they aſſume a cryſtalline form. If urged with a violent fire, they boil like fluids, and are reduced to vapour. Mercury has long been known to poſſeſs theſe properties. Goldſmiths often ſee gold and ſilver boil when in fuſion. M. Buffon obſerved, that when ſilver plates were expoſed to the focus of a large concave mirror, a white ſmoke aroſe from the ſurface of the plates. Meſſrs Macquer and Lavoiſier having cupelled ſilver in the focus of Tſchirnhauſen's lens, ſaw the metal exhale in ſmoke: a plate of gold expoſed to that ſmoke was completely ſilvered over. Gold expoſed to the ſame focus likewiſe exhaled a ſmoke which gilded ſilver. The chimnies of goldſmiths and aſſayers are filled with gold and ſilver in ſmoke. Copper, tin, lead, zinc, antimony, biſmuth, and arſenic, may be volatilized with great eaſe.

The ſurfaces of all melted metals are convex; and when they are in very ſmall maſſes, they compoſe perfect ſpheres. This effect is owing to the affinity of aggregation, which cauſes the particles of metals mutually to attract each other, and to the weakneſs of their tendency to combine with the body on which they are placed. This is a general property of fluids, and may be obſerved of oil in reſpect to water, and of water in reſpect to fat bodies.

When metals are expoſed in the air to the action of fire, they ſuffer conſiderable alterations; ſome ſooner,

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ſome later. Thoſe which ſuffer no ſenſible alteration on ſuch occaſions are called *perfect metals:* thoſe again which are entirely deprived of their metallic properties by this proceſs are called *imperfect metals.* This alteration of metallic matters which we call *oxidation*, is a real combuſtion. Like the combuſtion of all other combuſtible ſubſtances, it cannot be effected without the help of air. And when it has taken place for ſome time in a certain quantity of air, it cannot be continued, at leaſt without a ſupply of freſh air. The air in which metals are burnt becomes mephitic. The combuſtion of metallic ſubſtances is attended with a flame more or leſs lively. Zinc, arſenic, iron, gold, and ſilver, diſplay a diſtinct flame; ſuch likewiſe is that of lead, tin, and antimony, when they are expoſed to an intenſe heat. The longer metals are expoſed to the action of fire in contact with air, the more entirely are they diveſted of their metallic properties. Some of them ſeem to acquire the characteriſtics of earthy matters; and in this ſtate they are called *metallic earths* or *calces.* But the name of *metallic oxides* is more expreſſive of their real nature; for it is fully demonſtrated, that theſe burnt metals are not earths, as they were a few years ago believed to be, but combinations of the metals with oxigene. Metallic oxides have no longer the brilliancy and fuſibility of the original metals; nor have they any longer an affinity even with the metals to which they owe their formation. If urged with fire, they are volatilized, or melt into glaſs. This glaſs is the more tranſparent and infuſible, in proportion as the metals have been more completely oxidated; that is, in proportion as they contain a greater quantity of oxigene. Metallic

lic oxides combine with ſaline and earthy matters. Several of them poſſeſs the characteriſtics of ſaline ſubſtances. When arſenic is highly oxidated, it becomes a peculiar acid; the properties of which have been examined by Scheele and Bergman. Rouelle informs us, that the oxide of antimony diſſolves in water like arſenic.

Some metallic oxides are reduced to metals when expoſed to the action of fire, and give out, as they are reduced, an aeriform fluid, which is very pure vital air. We are indebted to M. Bayen for the firſt certain information which we obtained on this head. He obſerved, that when oxide of mercury was heated in cloſe veſſels, it gave out a good deal of air, and was then reduced to the ſtate of running mercury.

Dr Prieſtley, on examining this air, found it to be much purer than atmoſpheric air; and at the period of this diſcovery we may date the riſe of that accurate knowledge which we at preſent poſſeſs of the laws of the calcination of metals. Let us take a ſhort review of the phænomena which attend this operation. A metal cannot be *calcined*, unleſs it be in contact with air. The greater the quantity of the air brought into contact with the metal, the more completely is the metal *calcined*. A given quantity of air cannot ſerve to *calcine* any more than a given quantity of metal; as M. Lavoiſier has ingeniouſly ſhown by *calcining* lead by means of a reflecting mirror in a bell-glaſs containing a known portion of air. When a metal is *calcined*, it abſorbs a part of the ſurrounding air; for the mercury over which it is *calcined* riſes in the veſſel in proportion as the *calcination* proceeds. It is to this abſorption of oxigene that

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metallic calces owe the increaſe of weight which they gain by *calcination;* for when it is extracted from the oxide of mercury, that oxide returns to the ſtate of a metal, and ſuffers a loſs of weight preciſely equal to the weight of the vital air obtained from it by diſtillation. Theſe phænomena ſhow evidently that *calcination* is nothing but the combination of the metal with the baſe of pure air, or the oxigene contained in the atmoſphere. This combination is often effected merely by the contact of air and water in metals liable to ruſt. The reaſon why heat is neceſſary to the oxidation of moſt metals is, becauſe by diminiſhing the aggregative force by which the integrant parts of thoſe bodies adhere together, it increaſes in the ſame proportion their force of affinity or combination; and thus promotes the combination of the oxigene with the metal. In this operation, therefore, as in moſt ſolutions, heat is no more than an auxiliary. The air which has been once employed in the oxidation of a metal, can no longer contribute to maintain combuſtion; becauſe it is deprived of its vital air, the principle which rendered it ſerviceable to combuſtion and reſpiration. The greater the proportion of vital air contained in the atmoſpheric fluid, ſo much the ſooner will it reduce a given quantity of metal to an oxide. I have often obſerved, that by immerſing melted lead, biſmuth, &c. in a veſſel filled with vital air, a much greater quantity of metallic oxide may be obtained in a given time than if the metals were expoſed for the ſame ſpace to the action of atmoſpheric air. All of theſe facts, and a great many more, which will be found under the hiſtory of the different metals when we come to treat of them ſeparately,

rately, concur to prove that a metallic oxide is nothing but a chemical combination of a metal with the oxigene of the atmoſphere; that calcination is merely the act by which this combination takes place; and that as vital air is fixed on the occaſion, what remains of atmoſpheric air after it has contributed to the calcination of a metal is nothing but gas azote.

The reduction of metallic oxides by the uſe of combuſtible matters, farther illuſtrates and confirms this theory. To reduce a metallic oxide to a metal, it is often found neceſſary to heat it in a cloſe veſſel with ſome combuſtible matter, ſuch as fats, oils, charcoal, &c. On all ſuch occaſions the metallic oxide is decompoſed, and loſes the oxigene to which it owed its character as ſuch. In order to underſtand what paſſes on this occaſion, we muſt reflect, 1. That metals are not the moſt combuſtible bodies in nature; or, what is the ſame thing, that metals have not the greateſt poſſible affinity with oxigene. 2. That animal or vegetable combuſtible matters have a ſtronger affinity with oxigene than metallic ſubſtances have. 3. That, of conſequence, when a metallic oxide is reduced with the help of charcoal, the charcoal having a greater affinity with oxigene, or being more combuſtible than the metal, robs the oxide of the principle to which it owes its character, and cauſes it to paſs into the ſtate of a metal. And operations of this kind ſucceed beſt in cloſe veſſels; becauſe when the combuſtible matter is not brought into contact with air, it cannot burn without abſorbing the oxigene of the oxide. For this reaſon the pure carbonaceous matter which combines with the oxi-

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gene of the metallic ſubſtance, is changed into carbonic acid during the reduction of the metal.

Having given the hiſtory of the calcination of metals according to the modern theory, we cannot avoid taking ſome notice of Stahl's doctrine on this head, which was almoſt univerſally received among chemiſts till the period of the late diſcoveries concerning air and combuſtion. Stahl conſidered metallic ſubſtances as compounds of peculiar earths with phlogiſton. *Calcination* was, in his opinion, merely the diſengagement of the *phlogiſton;* and he thought that the reduction of metals reſtored to them the principle which they had loſt by *calcination.* This theory is directly contrary to the modern theory: it repreſents metals as compound ſubſtances; whereas the doctrine at preſent received conſiders them as ſimple bodies. According to Stahl, they loſe, when *calcined,* one of their component principles: but the facts on which the modern theory is founded, prove that they enter, on that occaſion, into a new combination. Laſtly, That great man imagined, that metallic oxides regained by reduction the *phlogiſton* of which the metals had been deprived by the action of fire: but the moderns have ſhown reduction to be merely the ſeparation of the oxigene which entered into combination with them when they were *calcined.*

After this ſlight compariſon of the two theories, let us attempt to ſhow which of them is ſupported by the greateſt number of facts. Stahl, while he was ſo eager to demonſtrate the exiſtence of *phlogiſton* in metals, ſeems to have overlooked the influence of air on their *calcination.* Beecher, Rey, Boyle, and ſeveral other chemiſts,

chemiſts, had, however, ſuſpected, before his time, that this element was the principal agent on the occaſion. And however ſatisfactory the theory of Stahl may have ſeemed till the æra of the new diſcoveries concerning air, yet it muſt always have appeared inconſiſtent with thoſe facts, which prove that air acts, and is a neceſſary agent in the *calcination of metals*. It is impoſſible to conceive how any body can acquire additional weight, in conſequence of loſing one of its conſtituent principles; and as gravity is one of the eſſential properties of all bodies, the ingenious explanation of this phænomenon which M. de Morveau has given in his Diſſertation on *Phlogiſton*, cannot be conſidered as fully ſatisfactory; eſpecially ſince it has been diſcovered that there is a portion of air in metallic oxides. From theſe facts, therefore, it appears that the pneumatic theory has by much the advantage over Stahl's. Macquer, with a judicious diſcretion which we cannot ſufficiently praiſe, attempted to reconcile the modern diſcoveries with the doctrine of *phlogiſton*. According to that celebrated chemiſt, metals never loſe their *phlogiſton* or ſuffer *calcination*, but when the pure air of the atmoſphere is precipitated, and combined with their ſubſtance; the light which they contain is then diſengaged: and when they are reduced, light, with the help of heat, expels the pure air which had entered into combination with them, and aſſumes its place. So that light and pure air may be conſidered as mutually precipitating one another. But as light, and that principle to which Stahl gave the name of *phlogiſton*, have not yet been ſhown to be the ſame, and as the exiſtence of light as a principle in combuſti-

ble bodies is equally uncertain, Macquer's opinion can be viewed in no other light but as an hypotheſis, which may be entirely overlooked, but cannot be admitted as well founded.

It is therefore at preſent an inconteſtible fact, that metallic oxides are compounds of the metals with oxigene: it is much to be wiſhed that we knew the various elective attractions ſubſiſting between that principle and the different metallic ſubſtances. M. Lavoiſier has already turned his attention to this important object of chemical reſearch: but his experiments are not yet ſufficiently numerous, nor their reſults ſufficiently accurate, to enable us to enter here into minute particulars on this head.

Metallic ſubſtances are altered by air; their ſurfaces loſe their luſtre, and are ſometimes covered over with ruſt. Chemiſts conſider ruſt as a metallic oxide. We will, oftener than once, have occaſion to review this ſubject, and to ſhow, that water in vapour oxidates a number of metallic ſubſtances, and that the carbonic acid of the atmoſphere combines with them after their calcination.

Water diſſolves certain metals; on others it has no power of action: when in vapour it contributes highly to the formation of ruſt on thoſe metals which are ſuſceptible of it. We know, from M. Lavoiſier's late diſcoveries, that it acts with great energy in effecting the oxidation of the moſt combuſtible metals, ſuch as zinc and iron; and that it is decompoſed on ſuch occaſions into oxigene, which combines with theſe metals; and into hydrogene, which is diſengaged in union with a large proportion of caloric;

ric; and of conſequence in the form of a very light gas.

Earthy matters appear to have no power of action on metallic ſubſtances; but they may be combined with metallic oxides by fuſion.

We are entirely ignorant of the manner in which the ſalino-terrene matters act on the ſubſtances which we are now examinnig.

The alkalis diſſolve ſome metals; they act, however, but weakly on moſt of them. Water or air appear to contribute greatly to the oxidation of thoſe metals which are liable to ſuch a change by the action of alkalis.

The acids produce a much greater alteration on metallic ſubſtances, diſſolving them with more or leſs difficulty. The ſulphuric acid then produces either hydrogenous or ſulphureous gas, according as it is diluted in water or concentrated. In the firſt inſtance, the water is decompoſed, and gives out hydrogenous gas, while it communicates its oxigene to the metals: in the ſecond, the acid itſelf is decompoſed; and while part of its oxigene combines with the metallic ſubſtances, the reſt remaining in union with the original proportion of ſulphur, conſtitutes by this means ſulphureous acid gas. When the ſulphuric acid is in either of theſe inſtances ſaturated with a metallic oxide, it forms what was formerly known by the name of *vitriol*; which when in cryſtals is to be conſidered as a compound of four bodies, namely, metal, oxigene, ſulphuric acid and water. Theſe metallic ſulphates are ſubject to many varieties in their colour, tendency to cryſtallization, ſolubility in water, ſuſceptibility of de-

compoſition by heat, by vital air,—the oxigenous part of which they abſorb, by the alkalis which ſeparate the metallic oxides, &c.

The nitric acid appears to act more quickly on metals than the ſulphuric acid; but it generally adheres to them with much leſs force. While it acts on theſe ſubſtances, a conſiderable quantity of nitrous gas is diſengaged; the metal is more or leſs oxidated; and is either precipitated, or remains in union with the acid. Stahl aſcribed this effect to the diſengagement of the phlogiſton of metals. Modern chemiſts now think that it is owing to the decompoſition of the nitric acid, and the ſeparation of part of its oxigene from the azote, its other principle; for we have elſewhere ſhown theſe two gaſeous bodies to be the component principles of the nitric acid. Theſe nitrates are more or leſs liable to cryſtallization, and decompoſition by heat, air, or water. Alkaline matters ſeparate the metallic oxides: the nitric, like the ſulphuric acid, has various degrees of affinity with the different metals. M. Prouſt has diſcovered that a number of metallic ſubſtances are inflamed when they come into contact with this acid.

The muriatic acid ſeldom acts with much energy on metals. The water which is in union with it, firſt oxidates the metals, producing by this means hydrogenous gas which is diſengaged from ſolutions effected by this acid. Theſe ſolutions effected by the muriatic acid are generally more permanent than either of the two laſt-mentioned acid ſolutions of metals, and uſually more difficult to decompoſe by heat. Sometimes they afford cryſtals, but ſeldom without conſiderable difficulty. The muriatic acid has a greater affinity than either of

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the two preceding acids with moſt metallic ſubſtances; which enables it to decompoſe both ſulphuric and nitric ſolutions of metals. Metallic muriates are often volatile.

The oxigenated muriatic acid oxidates moſt metals with a good deal of energy, on account of its containing an exceſs of oxigene, and that not very cloſely united with it. It diſſolves them in the ſame way in which water diſſolves ſalts, without effervescence.

The carbonic acid acts but faintly on metals; yet Bergman has ſhown it to be capable of combining with moſt of them. In nature we often find metals in combination with this acid; and theſe compounds are ſometimes in cryſtals; they are known by the name of *ſparry metal*, ſuch as ſparry iron, ſparry lead. But we rather give them names analagous to thoſe of the other ſalts formed by this acid, calling them *carbonate of iron*, *carbonate of lead*, &c.

The fluoric and the boracic acids have an equal tendency to combine with metallic matters: but the compounds which they then form are but little known.

Some among the combinations of metals with acids are ſuſceptible of cryſtallization; others cannot be made to aſſume any regular form. Fire decompoſes ſome of them; others ſuffer no alteration from that agent. Moſt of them are altered by air, the oxigenous part of which they abſorb. All of them are more or leſs ſoluble in water, and liable to decompoſition by that fluid, when a great quantity of it is cauſed to act on them, as has been obſerved by Macquer. All of them

are precipitated by alumine, barytes, magneſia, lime, and the alkalis; which ſubſtances have, in general, a ſtronger affinity than metallic oxides with the acids.

When ſeveral metals are employed to ſeparate other metals from their ſolutions, the metals that are precipitated regain their metallic form and luſtre; becauſe the oxigene which was united with them, while they were in a ſtate of ſolution, is ſeparated and combined with the precipitant metal, which is in its turn diſſolved in the acid. M. Lavoiſier, therefore, with good reaſon, conſiders theſe precipitations of metals by one another, as owing to their having various affinities with the oxigenous principle.

Neutral ſalts ſuffer but little alteration from metallic matters, when the two ſubſtances are brought together in the humid way; but when a mixture of a ſalt with a metal is heated, ſeveral of the ſalts are liable to be decompoſed. Several ſulphuric ſalts form ſulphur on ſuch an occaſion. M. Monnet is the only chemiſt who has obſerved antimony to be capable of effecting the decompoſition of neutral ſalts in this way. In a ſeries of experiments on this ſubject, I have found, that ſeveral other metals, ſuch as iron, zinc, &c. decompoſe ſulphate of potaſh, &c.

Nitre detonizes with moſt metallic ſubſtances, and oxidates them with more or leſs energy. The cauſe of this phænomenon is, that oxigene has a ſtronger affinity with moſt metallic ſubſtances than it has with azote. Metals oxidated by this ſalt are called *metallic oxids* by nitre. The alkaline baſe of this ſalt often diſſolves a part of the oxides.

Ammoniacal

Ammoniacal muriate is decompoſed by ſeveral metals, and by the oxides of almoſt all metallic ſubſtances. Bucquet, who made a ſeries of experiments on this ſubject, remarked, that all metallic ſubſtances on which the muriatic acid is capable of acting without an intermedium, are liable to be entirely decompoſed by ammoniacal muriate; that hydrogenous gas is diſengaged when theſe decompoſitions take place; and that metals which do not admit of ſolution by the common muriatic acid, are not liable to this decompoſition. The ammoniac obtained on theſe occaſions is always very pure and cauſtic.

Almoſt all combuſtible mineral matters combine readily with the metals. Hydrogenous gas colours them, and reduces ſome of their oxides; having, as Dr Prieſtley has proved by ſome very ingenious experiments, a greater affinity with oxigene than what moſt metals have. The reduction of metallic oxides by hydrogenous gas is accompanied with the production of a certain quantity of water from the combination of the hydrogene with the oxigene diſengaged from the metals.

Sulphur combines with moſt of the metals; the combination of ſulphur with a metal forms an artificial ore. When ores of this kind are moiſtened, or expoſed to humid air, they are vitriolized, or changed gradually into metallic ſulphates. Alkaline ſulphure diſſolves any metal. Sulphurated hydrogenous gas colours and decompoſes metallic oxides, reducing them at the ſame time by the abſorption of their oxigene.

Metals combine more or leſs readily with one another: the reſults are mixtures, the properties of which render them very uſeful in the arts.

§ VI. *Methodical Diviſion of Metallic Subſtances.*

AS metallic ſubſtances are pretty numerous, it appears neceſſary to divide them into certain orders, and to diſtinguiſh metals poſſeſſing ſimilar properties from thoſe of which the properties are different. We may conſider *ductility* as the firſt characteriſtic of metals. Such metallic ſubſtances as poſſeſs not this property, or poſſeſs it but in a very inferior degree, have received the appellation of *ſemi-metals*. Thoſe, again, which are highly ductile, are called *metals*. The ſemi-metals are either very brittle under the hammer, or in a ſmall degree malleable. This diſtinction occaſions a ſubdiviſion of theſe ſubſtances. Metals may be alſo ſubdivided, in reſpect of the manner in which they are affected by fire. Some metals, when heated in the air, are eaſily oxidated: others again ſuffer no alteration when they are treated in the ſame manner. The former are *imperfect metals*; the latter *perfect metals*. That we may not multiply theſe diviſions as we proceed in our hiſtory of metallic ſubſtances, we ſhall here give a table, in which metals are claſſed according to their natures. As the names, however, of *ſemi-metals* and *imperfect metals*, evidently owe their origin to the follies of alchemy; we ſhall entirely reject them, and adopt new diviſions founded ſolely on the varying *ductilities*

lities of metals, and their different *affinities with oxigene.* We divide the ſeventeen metals into five ſections, without including uranite or ſeveral other metallic matters which are ſaid to have been lately diſcovered, but of which the exiſtence has not yet been ſufficiently aſcertained.

Metallic

Metallic Subſtances are either

SECT. I.

Brittle and Acidifiable Metals.

Arſenic.
Tungſten.
Molybdena.

SECT. II.

Brittle and Non-Acidifiable Metals.

Cobalt.
Biſmuth.
Nickel.
Manganeſe.
Antimony.

SECT. III.

Semi-ductile and Oxidable Metals.

Zinc.
Mercury.

SECT. IV.

Ductile and eaſily Oxidable Metals; or

Tin.
Lead.
Iron.
Copper.

SECT. V.

Metals exceedingly Ductile, and not Oxidable, without extreme difficulty.

Silver.
Gold.
Platina.

CHAP.

CHAP. VI.

Of Arſenic and its Acid.*

ARSENIC is placed at the head of the brittle and acidifiable metals, becauſe it bears a conſiderable relation to ſalts. Kunckel thought it to be a coagulated aquafortis. Beccher and Stahl conſidered it as a ſaline matter. Scheele has proved that it forms a peculiar acid; and Brandt and Macquer have ſhown it to be a genuine metal. When arſenic poſſeſſes all the properties natural to it, it has all the characteriſtics of a metallic matter. It is then perfectly opaque, and has the gravity and luſtre which diſtinguiſh metallic ſubſtances. Native

* We give the the name of *arſenic* to the ſemi-metallic matter commonly known by the name of *regulus of arſenic*. This laſt denomination is improper and ought to be laid aſide. What is called *white arſenic* is the oxide of this metal. F.

Native arſenic is often found in black maſſes, almoſt without luſtre, and very heavy: it has ſometimes the diſtinguiſhing luſtre of metals, and it then reflects the colours of the rainbow: its fracture is ſtill more brilliant, and ſhows it to conſiſt of a great number of ſmall ſcales. When theſe ſcales or ſhells are obſervable on the exterior part of the maſs, it is then called *teſtaceous arſenic*, or improperly *teſtaceous cobalt*, becauſe formerly when the metallic character of arſenic was unknown, and its oxide was obtained in a large proportion from cobalt ore, teſtaceous arſenic was thought to be cobalt ore. Virgin arſenic is very eaſily known when it has the metallic luſtre, and is in ſmall ſcales; but when it is black, and its texture cloſe grained, the only way of diſtinguiſhing it is by its gravity, which is very conſiderable, and by obſerving whether or not it is diſperſed in white ſmoke, having a ſtrong ſmell of garlic when laid on burning coals. Great plenty of this laſt kind is found *at St Marie aux Mines*. It is mixed with grey ſilver ore. It is likewiſe found in the cobalt mines of Saxony, and at Andrarum in the province of Schonem in Sweden.

Arſenic is ſometimes found in nature in a white oxide, which is alſo of a vitreous appearance, but oftener in the form of a light duſt, or mixed with ſome particular earths. This oxide is likewiſe found at *St Marie aux Mines*. It is known by its white ſmoke, and by the garlic ſmell which it diffuſes when thrown into the fire.

Arſenic is often combined with ſulphur; it then forms *orpiment* and *realgar*, or the yellow and the red ſulphurated oxides of arſenic. Native *orpiment* appears in yellow,

low, brilliant, and ſeemingly talcky maſſes, of various ſizes and various degrees of brilliancy: it is often mixed with *realgar*, and it ſometimes approaches to green. *Realgar* is of a red colour, more or leſs lively and tranſparent, and often cryſtallized in bright needles. A good deal of it is found at Quito and on Mount Veſuvius. The only difference between theſe two ſubſtances ſeems to be, that the one has been formed by a more intenſe heat than the other.

Miſpikel, or arſenical pyrites, is the laſt ore of arſenic. It contains this metal in combination with iron. *Miſpikel* is ſometimes found in cubic cryſtals, but oftener without any regular form. This ore is of a white, *chatoyant* colour. Wallerius calls it white cubic arſenic.

Arſenic is alſo found among cobalt, antimony, tin, iron, copper, and ſilver ores.

Pure arſenic, called alſo *regulus of arſenic*, is of a blackiſh grey colour, and reflects the colours of the rainbow. It is very ponderous, and very friable.

When arſenic is expoſed to fire in cloſe veſſels, it is ſublimed, but not deconſpoſed: It is even one of the moſt volatile metallic matters. When ſlowly ſublimated, it cryſtallizes in regular tetrahædral figures. When arſenic is heated in the air, it is very ſoon converted into an oxide, and diſſipated in the form of a white ſmoke, which exhales a ſtrong ſmell of garlic. Red arſenic burns with a bluiſh flame. On this occaſion, it combines with the oxigene of vital air, and forms a compound known by the name of *white arſenic* or *calx of arſenic*, and which we call oxide of arſenic. This is the reaſon why arſenical ores of cobalt give out in the furnace

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a great deal of white ſmoke, which is condenſed in the chimney into a white, ponderous, vitrified matter, that is depoſited in layers, and is ſold very improperly under the name of arſenic. It is properly a vitreous oxide of arſenic.

The oxide of arſenic is eſſentially different from the oxides of all other metallic ſubſtances; it has a very ſtrong, and even a cauſtic taſte; it is a ſtrong poiſon. When expoſed to fire in cloſe veſſels, it is volatilized by a moderate heat into a white cryſtalline powder, known by the name of *flowers of arſenic*. When the heat is a little ſtronger, it is vitrified as the ſublimation takes place. The glaſs produced is very tranſparent, and cryſtallizes into flat triangular ſolid figures, with truncated angles. It very ſoon loſes its tranſparency in the air. No metallic oxide is really volatile of itſelf; that of arſenic is the only one which exhibits ſuch a property; it is at the ſame time very fuſible and very vitrifiable. Beccher attributed the gravity and volatility of arſenic to a peculiar principle, which he called *mercurial* or *arſenical earth*, and of which Stahl has not been able to demonſtrate the exiſtence.

Arſenic in the ſtate of regulus does not act in a ſenſible manner on combuſtible bodies; but the oxide of arſenic produces a ſenſible alteration upon them, and at the ſame time reſumes its metallic luſtre. Stahl thought, that, on this occaſion, the combuſtible body reſtored to the arſenic the phlogiſton which it had loſt by calcination: But the moderns have proved, that the oxide of arſenic is a compound of arſenic and oxigene, and that the combuſtible body, having a greater affinity with oxigene than arſenic has, in conſequence of

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its poſſeſſing that property, cauſes the oxide of arſenic to return to the metallic ſtate. To ſucceed in reducing oxide of arſenic, it muſt be made into a powder, and baked into a paſte with black ſoap; this paſte is to be put into a matraſs, and placed on a ſand bath; a moderate heat muſt at firſt be applied, in order to dry up the oil: when humid vapours ceaſe to exhale, the fire muſt be increaſed in order to ſublime the arſenic; the matraſs is then to be broken, and the upper part of it is found to contain a cake, having the appearance and metallic luſtre of arſenic: moſt of the carbonaceous matter of the oil remains at the bottom of the matraſs.

Arſenic, when expoſed to the air, becomes ſenſibly black. Vitrified oxide of arſenic, on ſuch an occaſion, loſes its tranſparency, and acquires a lacteous appearance, ſuffering at the ſame time a ſort of efflorescence.

Arſenic does not appear to be liable to ſuffer from the attacks of water, but its oxide is readily diſſolved in this menſtruum: Warm water diſſolves rather leſs of it than cold: The ſolubility of this ſubſtance varies alſo according as it has been more or leſs perfectly oxidated. When a ſolution of oxide of arſenic is ſlowly evaporated, it gives yellowiſh cryſtals in tetrahædral figures, more or leſs regular: no other metallic oxide is known to diſſolve ſo readily in water. This property of oxide of arſenic, together with its ſapidity, renders it not very different in nature from ſaline matters.

Oxide of arſenic unites readily enough with earths by fuſion; it becomes fixed with them, and accelerates their vitrification; but all glaſſes into the compoſition of which it enters are liable to be very ſoon ſullied in the air. It is not known in what manner

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the ſalino-terrene ſubſtances act on arſenic and on its oxide. The cauſtic fixed alkalis, though they do not act in any ſenſible manner on arſenic, diſſolve its oxide very readily. Macquer, in his ingenious experiments on this matter (*Academ. Mem.* 1646,) has obſerved, that when powdered oxide of arſenic is boiled in liquor of fixed nitre, or a ſolution of cauſtic potaſh, it is completely diſſolved, and forms a brown gelatinous fluid, the conſiſtency of which gradually thickens. This compound, to which he gives the name of *liver of arſenic*, is not ſuſceptible of cryſtallization; it becomes hard and brittle: it is liable to deliquiate, and ſoluble in water: ſome brown flakes are precipitated when it is diſſolved: When urged by a ſtrong fire, liver of arſenic loſes the arſenic which it contains. Acids decompoſe it: Soda mixed in the ſame manner with arſenic, exhibits the ſame effects; but its ſolution afforded Macquer irregular cryſtals, the form of which he found it impoſſible to determine.

The ſulphuric acid cold, even though it be concentrated, produces no effects on arſenic; but when boiled with this ſemi-metal in a retort, the acid gives out a good deal of ſulphureous gas; after that, a little ſulphur is ſublimed, and the arſenic is then found to be reduced to an oxide, but without being diſſolved. The ſulphuric acid likewiſe diſſolves oxide of arſenic when it is concentrated and boiling; but when the ſolution cools, the oxide is totally precipitated. When it enters into this combination, it becomes fixed in a very conſiderable degree. Bucquet aſſerts, that when it is entirely freed of the acid by lixiviation, it regains all its original properties.

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The nitric acid, when applied to arſenic, acts vigorouſly upon it, and reduces it to an oxide. When aſſiſted by a moderate heat, the ſame acid likewiſe diſſolves oxide of arſenic in a pretty conſiderable proportion: though ſaturated with either of theſe ſubſtances, it retains its natural ſmell: when violently evaporated, it produces a ſalt which, according to Bucquet, has no regular form, but is ſaid by M. Baumé to be partly cubic, and partly cut into diamond points. Wallerius ſays its cryſtals reſemble thoſe of nitrate of ſilver. Nitrate of arſenic powerfully attracts the moiſture of the air: it does not detonize on the coals, nor is it liable to decompoſition by water or acids: the alkalis do not cauſe it to yield a precipitate; yet, according to Bucquet, they decompoſe it; for when a nitric ſolution of arſenic, mixed with an alkaline lixivium, is evaporated, common nitrate and arſeniate of potaſh is obtained. We ſhall hereafter ſee, that chemiſts, being all very much perplexed with the ſingular nature of the ſolutions of arſenic and oxide of arſenic in acids, never diſcovered what paſſed when this oxide was combined with the nitric acid, nor once ſuſpected the production of the arſenic acid. Here we would only remark, that the oxide of arſenic deprives the nitric acid of a great part of its oxigene.

The muriatic acid, with the help of fire, diſſolves both arſenic and its oxide, according to Bucquet. Either fixed or volatile alkali is capable of precipitating this combination. M. Baume ſays, that regulus of arſenic is ſoluble in the boiling muriatic acid, and afterwards is precipitated in a yellow powder, reſembling ſulphur. Meſſ. Bayen and Charlard, in their

experiments on tin, have eſtabliſhed it as a fact, that, when cold, the muriatic acid is entirely incapable of acting on arſenic. Powdered arſenic, caſt upon oxigenated muriatic acid, burns with a white flame.

We are entirely ignorant how the other acids affect arſenic or its oxide. A mixture of arſenic with nitre, put into a red hot crucible, gives a ſmart detonation: the nitric acid calcines and burns the ſemi-metal. The fixed alkali, which was the baſe of the nitre, and the oxidated arſenic, combined in part with the fixed alkali, are found in the crucible after the operation.

A mixture conſiſting of equal parts of oxide of arſenic and nitre, diſtilled in a glaſs retort, gives ſpirit of nitre in very red vapours. The acid cannot be condenſed till a little water be put into the ball of the retort, which gives it a blue colour. Beccher, Stahl, and Kunckel, have deſcribed this operation. Macquer repeated it with care; and on examining the reſidue of which thoſe chemiſts had made no mention, found it to be a peculiar neutral ſalt, and has given it the name of *arſenical neutral ſalt*; it ſhould be called arſeniate of potaſh. When this ſalt is diſſolved in water, and the ſolution evaporated in the air, it gives very regular cryſtals in tetrahædral priſms, terminating in pyramids with four equal faces. The form of the cryſtals ſometimes varies.

When arſeniate of potaſh is expoſed to fire, it eaſily melts, and remains in a ſtate of fuſion without being alkalized, and without loſing any part of its arſenic by volatilization; from air it ſuffers no ſenſible alteration. It is much more ſoluble in water than pure oxide

oxide of arſenic; and more of it diſſolves in hot than in cold water.

None of the acids decompoſe it pure; but what they cannot effect pure, they perform by double affinity. If a ſmall portion of ſulphate of iron or *martial vitriol* be mixed with a ſolution of this ſalt, a double decompoſition and a double combination follow. The ſulphuric acid forſakes the iron in order to combine with the potaſh, and the arſenic acid is ſeparated from the alkali, and combines with the iron oxide. Combuſtible matters decompoſe arſeniate of potaſh with great energy.

The oxide of arſenic likewiſe decompoſes nitrate of ſoda by diſtillation, forming with its baſe, arſeniate of ſoda, which, according to Macquer, is very little different from arſeniate of potaſh, and cryſtallizes preciſely in the ſame manner. This oxide acts in the ſame way on ammoniacal nitrate, and combines with its baſe to conſtitute ammoniacal arſeniate. It was thought that a great many precautions were neceſſary in performing this operation, becauſe in cloſe veſſels ammoniacal nitrate detonizes by itſelf: but M. Pelletier has proved that even ſeveral pounds of it may be made together without any danger. Macquer's diſcovery of the arſeniacal neutral ſalt led the way to the diſcovery of the arſenic acid; for that illuſtrious chemiſt obſerved and aſſerted that the oxide of arſenic acted the part of an acid in this ſalt. But it is to Scheele, as we ſhall hereafter mention, that we are really indebted for an accurate knowledge of theſe combinations.

Oxide of arſenic does not decompoſe alkaline muriates. Like arſenic itſelf, it ſeparates ammoniac from ammoniacal muriate, but not without great difficulty.

The action of combuſtible mineral matters on arſenic has not yet been examined. It appears that the oxide of this metal may be reduced by hydrogenous gas, which has more affinity than arſenic with oxigene, or the baſe of vital air.

Oxide of arſenic combines very readily with ſulphur. When theſe two ſubſtances are melted together, they form a yellow or red volatile body, the taſte of which is rather weaker than that of pure oxide of arſenic, but which is not more ſoluble in water than that ſubſtance. This yellow ſulphurated oxide of arſenic has been called *factitious orpin or orpiment:* It cryſtallizes in tetrahædral figures like vitreous oxide of arſenic. When red, it is called *realgal, realgar, factitious rizigal* or *red arſenic.* The name which we give to this compound is red ſulphurated oxide of arſenic. Some chemiſts have imagined it to differ from the yellow or orpiment, only in containing more ſulphur; but Bucquet has ſhown, that the compound of ſulphur and oxide of arſenic becomes red after being melted; for to expoſe orpiment to a pretty ſtrong heat is all that is neceſſary to make it paſs into the ſtate of *realgar.* I am convinced that realgar is far from being ſo volatile as orpiment; for when this mixture of oxid of arſenic and ſulphur is ſublimated in a matraſs, red inflated laminæ are found at the bottom, which appear evidently to have been melted. There is no difference between artificial orpiment and realgar, and the ſame ſubſtances natural. They are liable

liable to be decompoſed by lime and the alkalis, which have a greater affinity with ſulphur than the oxide of arſenic has: yet this oxide, like the acids, poſſeſſes the property of decompoſing alkaline ſulphures.

All the properties of the oxide of arſenic concur to ſhow, that when this metallic combuſtible matter is united with the baſe of vital air, it acquires the character of a ſaline ſubſtance: The theory which we laid down, when treating of ſalts in general, is therefore confirmed by theſe facts. Macquer, in his valuable diſcoveries concerning arſeniate of potaſh, obſerved, as was before mentioned, that oxide of arſenic acted the part of an acid in the compoſition of that ſalt: but it was hard to conceive, how that oxide, when diſſolved in potaſh without any intermedium, could differ ſo conſiderably from the combination of the ſame ſubſtances produced by decompoſing nitre with oxide of arſenic.

The diſcovery of the oxigenated muriatic acid ſuggeſted to Scheele, that ſomething analogous might happen when nitre was diſtilled with oxide of arſenic. The nitric acid, he imagined, ſeized what phlogiſton ſtill remained in the oxide; upon which the oxide was left in the ſtate of the peculiar acid which we call the arſenic acid. He prepared this acid by a proceſs analogous to that by which he produced the oxigenated muriatic acid. One part of that proceſs conſiſted in diſtilling a mixture of the oxigenated muriatic acid with oxide of arſenic. According to him, the muriatic acid then ſeizes the phlogiſton of the oxide, leaving it in the ſtate of an acid. The arſenic acid may be alſo prepared by diſtilling ſix parts of nitric acid upon one of its oxide. The acid gives out a good deal

of nitrous gas; and the oxide of arſenic aſſumes the character of an acid. It muſt be expoſed for a conſiderable time to a ſtrong heat, in order that the ſuperfluous nitrous gas may be diſengaged.

What happens in theſe operations is conſiderably in favour of the modern doctrine. In fact, on one hand, one can ſcarce agree with Stahl in acknowledging the exiſtence of phlogiſton in oxide of arſenic; and again, nothing can be more natural than the manner in which the modern doctrine repreſents this oxide as paſſing from an oxide to an acid, by the influence of ſpirit of nitre, or the oxigenated muriatic acid. Oxide of arſenic appears to have a great affinity with oxigene, when it is not already ſaturated with it. When diſtilled with the nitric, or the oxigenated muriatic acid, it deprives either of theſe acids of its oxigene. The more oxigene it contains, the nearer does it approach in nature to ſaline ſubſtances; and, when fully ſaturated, it acquires all the diſtinguiſhing properties of acids; which, as we have ſhown above, are nothing but combuſtible matters combined with oxigene, which communicates to them their ſaline properties. From this theory it may be eaſily underſtood why oxide of arſenic, when not ſaturated with oxigene, but ſimply oxidated by fire, does not form arſeniate of potaſh; and why it never compoſes that ſalt till after being previouſly treated with the acids which it decompoſes, by depriving them of their oxigene with the help of heat.

The arſenic acid is very different from common oxide of arſenic. Its ſapidity is ſtronger. Fire fixes it; and this proceſs is employed to ſeparate it entirely from any remainder of oxide of arſenic which it may ſtill

ſtill retain. It is doubtleſs by acquiring the properties of an acid that oxid of arſenic becomes of a fixed nature when combined with the ſulphuric acid. The arſénic acid melts into a tranſparent glaſs: it communicates its fuſibility to earthy matters; and it even appears capable of corroding glaſs. It communicates a faint red tinge to blue vegetable colours. I have obſerved, that, when expoſed to the air, it loſes its tranſparency, waſtes away in ſcaly fragments, which are generally pentagonal, and gradually attracts moiſture. It diſſolves in two parts of water: It combines readily with lime,—and with barytes and magneſia, but with more difficulty. With the alkalis it forms neutral ſalts, which, according to Bergman, are decompoſed by lime. The ſame chemiſt informs us, that barytes and magneſia have likewiſe a greater affinity with this acid than the alkalis: but a great many more experiments muſt be made before we can be fully acquainted with all the properties of the arſénic acid. M. Pelletier prepared this acid by decompoſing ammoniacal nitrate with oxide of arſenic. The ammoniacal arſeniate thus formed was deprived of its ammoniac by heat; and after it had been for ſome time expoſed to the action of fire, the arſénic acid remained pure and ſolitary in the bottom of the retort.

Bergman obſerves, that the ſpecific gravity of arſenic varies from that which diſtinguiſhes it in the metallic ſtate, to that which belongs to it when an acid: The following are the gravities which he aſcribes to it in its various modifications: regulus of arſenic 8,308: vitreous oxide of arſenic 5,000: white oxide of arſenic 3,706: arſenic acid, 3,391.

Arſenic is made uſe of in ſeveral of the arts, more eſpecially in dyeing. Arſeniate of potaſh is likewiſe uſed; and M. Baumé has long manufactured it for the purpoſes of the arts.

The facility with which oxide of arſenic diſſolves in water or any aqueous fluid, renders it a very dangerous poiſon. The following ſymptoms appear when a perſon has taken this poiſon: His mouth becomes dry, his teeth are ſet on edge, and his throat contracted; he has an involuntary ſalivation, and an acute pain in his ſtomach: he feels an extreme thirſt, and naufeas and vomits ſlimy bloody matters: he feels at the ſame time very intenſe colic pains; his body is bedewed with a cold ſweat, and he is agitated with convulſions. Theſe ſymptoms are ſoon followed by death; and oxide of arſenic is known certainly to have been the cauſe, by examining the aliments in which it is ſuſpected to have been given. The preſence of the poiſon is determined by drying part of thoſe aliments, and throwing it on burning coals: if impregnated with arſenic it exhales a white ſmoke, having a ſtrong ſmell of garlic.

It was formerly the practice to make perſons poiſoned with arſenic drink milk, or ſome mucilaginous liquid or mild oil, with a deſign to relax the viſcera, and to diſſolve and carry off moſt of the arſenical poiſon. Navier, a phyſician at Chalons, who has laboured to diſcover ſome remedy capable of counteracting the poiſonous effects of oxide of arſenic, has found a matter which combines with this ſubſtance in the humid way, ſaturates it, and almoſt totally diveſts it of its cauſticity. That ſubſtance is calcareous or alkaline ſulphure; and this ſulphure is ſtill better for the purpoſe

if

if it be impregnated with a little iron. A ſolution of oxide of arſenic decompoſes ſulphures without exhaling any ſmell: the oxide combines with the ſulphur to form orpiment, entering at the ſame time into union with the iron, if the ſulphure contain any. Navier preſcribes a dram of *liver of ſulphur* in a pint of water, to be taken in glaſſes, or five or ſix grains of dry ſulphure of potaſh in pills, with a glaſs of warm water above each pill. When the firſt ſymptoms are removed, he recommends the uſe of ſulphureous mineral waters. From his own experience he informs us, that they have very happy effects in removing the tremors and paralytic affections, which are the uſual conſequences of taking arſenic, and end in conſumption and death. Navier likewiſe approves of the uſe of milk, becauſe it diſſolves oxide of arſenic as well as water; but diſapproves of oils, becauſe they do not diſſolve it.

CHAP.

CHAP. VII.

Of Molybdena, and the Molybdic Acid.

WE give the name of *molybdena* to a new ſemi-metal diſcovered by M. Hielm, which is obtained from the mineral ſubſtance known by the ſame name. This ſubſtance is not to be confounded with common *lead ore*, plumbago, or the matter of the black pencils uſed in drawing, which is at preſent known under the peculiar name of *carbure of iron*. The confounding of theſe matters has produced that contrariety which appears in the researches of all the chemiſts who have examined them, from Pott to Scheele. It is to be obſerved, that *carbure* of iron or *plumbago* is much more common than molybdena, of which there are but a very few ſpecimens in the cabinets of the curious; and that therefore the experiments of chemiſts, except thoſe

thoſe of Meſſrs Quiſt and Scheele, have been almoſt always made on the former.

It is very difficult to diſtinguiſh the one from the other by external appearance. Molybdena, however, feels rather more greaſy than the other ſubſtance: it conſiſts of hexagonal ſcaly laminæ of various ſizes, and ſcarce adhering together. It ſpots the fingers, and leaves bluiſh or ſilver grey marks upon paper. When reduced to a powder,—which, however, its claſticity renders difficult to be done—the powder is bluiſh: it may be cut with a knife; it does not break into pieces, nor has a granulated contexture like plumbago. Scheele's proceſs for pulveriſing ore of molybdena was, to throw a little ſulphate of potaſh into a mortar together with this ore, and afterwards to waſh the powder with warm water, which carried off the ſalt, leaving the ore pure. The analyſis of this ore, effected in various ways, ſhows it to be a compound of ſulphur with the ſemi-metal which we are conſidering: but it is very difficult to obtain the ſemi-metal ſeparate. The illuſtrious Scheele could not reduce this metallic oxide, either with black flux and coal, or with borax and coal, or with oil. Bergman informs us, that M. Hielm was more ſucceſsful, and obtained ſo much of the metal as to be able to diſtinguiſh its properties; but ſince that, M. Hielm has publiſhed nothing concerning the matter himſelf.

M. Pelletier, in his experiments concerning the reduction of the oxide of molybdena, and the nature of the molybdic acid, could never obtain a lump of molybdena; what he obtained was a friable, blackiſh, agglutinated matter, of a metallic luſtre: through a magnifier,

niſier, it appeared to conſiſt of ſmall, round, grey, ſparkling grains, which M. Pelletier takes to be the metal, or pure molybdena. Manganeſe has never yet been obtained in any other form but that of ſmall grains. The following are the properties which this metal has been found to poſſeſs. It is grey, and conſiſts of ſmall agglutinated brittle grains, which are very infuſible. When heated in the air, it is converted into a white volatile oxide, which, like oxide of antimony, cryſtallizes by ſublimation into ſparkling needled priſms. This oxide becomes acid when it is ſuperſaturated with oxigene, forming that ſaline product which is ſo well known from Scheele's reſearches. The nitric acid eaſily calcines molybdena, converting it into a white oxide, or even into the molybdic acid. Oxide of molybdena becomes blue and ſparkling when it is reduced to a metallic ſtate. Alkalis, with the help of heat, oxidate and diſſolve this metal. It may be mixed with lead, copper, iron, and ſilver; the mixtures thus made up are granulated, greyiſh, and very friable. Laſtly, in union with ſulphur, it forms ſulphure of molybdena; a compound which is entirely the ſame with the ore of this metal, improperly known by the name of *molybdena* and *potelot*. As this laſt is the ore on which Scheele made his experiments, and as it is from this mineral, which is much better known than the metal which it contains, that he prepared the molybdic acid, we ſhall examine its properties more particularly.

When native *potelot*, or ſulphure of molybdena, is expoſed to fire in an open veſſel, it exhales ſulphur, and evaporates almoſt totally in white ſmoke. When heated

ed in a ladle with the blow-pipe, it gives out the ſame ſmoke; which is condenſed into yelloviſh cryſtalline laminæ, and aſſumes a blue colour when brought into contact with combuſtible bodies. M. Pelletier, upon calcining ſulphure of molybdena in a crucible, with another crucible covering it, obtained white ſparkling needled cryſtals, reſembling that matter which is called *ſilver flowers of antimony*. This ſublimated oxide of molybdena poſſeſſes all the diſtinguiſhing characteriſtics of an acid; but this would be too tedious and too expenſive a proceſs for the preparation of the molybdic acid.

The ſaline earths and the fixed alkalis, when melted with ſulphure of molybdena, diſſolve both the ſulphur and the metal.

Several of the acids produce remarkable alterations on this ore. The ſulphuric acid, concentrated, reduces the metal to an oxide, giving out a quantity of ſulphureous acid by the way of ebullition.

The muriatic acid has no power of acting on this mineral.

The acid of arſenic, when diſtilled with ſulphure of molybdena, is robbed of its oxigene, which combines with the ſulphur to form ſulphureous acid, volatilizes into *orpiment* with the remaining part of the ſulphur, and changes part of the molybdena into molybdic acid, leaving, however, moſt of it ſtill in the metallic ſtate. From this experiment M. Pelletier concluded, that molybdena is in the metallic ſtate in its ore.

On diſtilling 30 ounces of nitric acid, diluted in water with an ounce of molybdena at 5 different times; that

that is, 6 ounces of the acid at a time, a great quantity of nitrous gas is diſengaged, and there remains in the retort a white powder; which muſt be waſhed with a ſufficient quantity of cold diſtilled water, in order to carry off what remains of the extraneous acid, and is ſoluble in cold: ſix drams and an half of pure molybdic acid remain after this edulcoration. Scheele, to whom we owe this diſcovery, gives it as his opinion, that the nitric acid on this occaſion ſeizes the phlogiſton, and flies off in red vapours. It likewiſe burns the ſulphur of the molybdena; for which reaſon, the water uſed in waſhing the acid of molybdena contains ſulphuric acid, which may be obtained by evaporation in a concentrated ſtate, ſtill retaining, however, a little molybdena in ſolution: this ſubſtance communicates to the evaporated liquid a ſparkling blue colour. My opinion is, that, in this inſtance, and in all others in which nitric acid, being diſtilled on any ſubſtance, reduces it to an acid, the nitric acid is decompoſed; and that the diſengagement of the nitrous gas, and the formation of the ſulphuric and the molybdic acids, are owing to the oxigene of the nitric acid being ſeparated and fixed in the molybdena.

The molybdic acid obtained by the ſame proceſs is in the form of a white powder; its taſte faintly acid and metallic. When heated in a ladle with the blowpipe, or in a crucible with acceſs of air, it is volatilized in a white ſmoke, which condenſes into needled cryſtals, and part of it fixes on the ſides of the crucible. Even after edulcoration it retains a portion of ſulphureous acid: which may, however, be completely

ly diſengaged from it by the application of a ſtrong heat.

This acid is ſoluble in boiling water; Scheele diſſolved a ſcruple of it in 20 ounces of water. The taſte of this ſolution is ſingularly acid, and almoſt metallic: it reddens tincture of turnſole, decompoſes a ſolution of ſoap, and precipitates alkaline ſulphures, or *livers of ſulphur*: it becomes blue, and loſes its conſiſtency when expoſed to cold.

The concentrated ſulphuric acid, with the help of heat, diſſolves a large proportion of the molybdic acid. This ſolution, when cooled, becomes thick, and aſſumes a beautiful colour. Theſe two phænomena may be cauſed to diſappear by heating; but they appear again when the liquor is again cooled. If this combination be expoſed to an intenſe heat in a retort, the ſulphuric acid will volatilize, leaving the molbydic acid dry in the bottom of the veſſel.

The nitric has no power of acting on the molybdic acid.

The common muriatic acid diſſolves a large proportion of it. This ſolution affords a deep blue reſidue, when it is diſtilled to dryneſs: the reſidue, if urged with heat, is ſublimed, and one part of the ſublimate is white, the other bluiſh. The ſublimate is liable to deliquiate, and tinges metals: the muriatic acid is oxigenated when it paſſes into the receiver. It is eaſy to conceive, that in this operation the muriatic acid deprives the molybdic of part of its oxigene; and of conſequence part of the molybdic acid paſſes into the ſtate of molybdena.

The

The molybdic acid, with the help of heat, decompoſes the alkaline nitrates and muriates, by diſengaging their acids, and combines with their baſes to form neutral ſalts; the properties of which Scheele has not fully examined. This acid likewiſe diſengages the carbonic acid from the three alkalis, and forms neutral ſalts with their baſes.

Though Scheele does not make us acquainted with all the properties of theſe neutral ſalts, to which we give the names of *molybdates of potaſh, of ſoda, of ammoniac, &c.*; yet he takes notice of three of them, which may be uſed as general characteriſtics. He has obſerved, 1. That fixed alkali renders the molybdic acid more ſoluble in water. 2. That the ſame ſalt hinders the molybdic acid from being volatilized by heat. 3. That molybdate of potaſh is precipitated by cooling in ſmall granulated cryſtals; and that it may be alſo ſeparated from its ſolvent by the ſulphuric and the muriatic acids.

The molybdic acid decompoſes barytic ſulphate and nitrate. The barytic molybdate formed on theſe occaſions is ſoluble in water.

The molybdic acid appears to decompoſe ſulphate of potaſh in part; and diſengages from it by a ſtrong heat, a little ſulphuric acid.

The molybdic acid diſſolves ſeveral metals, and aſſumes a blue colour, in proportion as it gives up to them a part of its oxigene. It precipitates various metallic ſolutions, &c. M. Klaproth has found it in combination with lead, in the yellow ſpathoſe ore of lead.

CHAP.

CHAP. VIII.

Of Tungſten, and the Tungſtic Acid.

THAT mineral which the Swedes call *tungſten*, and to which ſeveral naturaliſts, and particularly Bergman in his Sciagraphy, have given the name of *ponderous ſtone*, *lapis ponderoſus*, has been conſidered by Cronſtedt as an iron ore, and has received from him the denomination of *ferrum calciforme*, *terrâ quadâm incognitâ intime mixtum*. Moſt of the German naturaliſts have reckoned it among the tin ores, under the name of *white tin cryſtal*, or *zinn ſpath*; and in almoſt all cabinets of natural hiſtory it is ranked as a kind of tin.

No ſtrict analyſis of this mineral had been made before Scheele attempted it. That chemiſt, on examining

ning this pretended tin ore, diſcovered it to conſiſt of a peculiar acid in combination with lime. Bergman made a ſeries of experiments on this matter with the ſame reſults. This diſcovery was made in the year 1781. Thoſe two Swediſh chemiſts were induced, from an examination of the properties of this mineral, to think the acid which they found it to contain of a metallic nature.

Since that period, Meſſrs D'Elhuyar of the Royal Society of Biſcay, M. Angulo of the Academy of Valladolid, and M. Crell, have repeated the Swediſh chemiſts experiments with the ſame reſults. From what we have already ſaid of this natural ſalt and its acid, the reader will have perceived, that what the Swedes call *tungſten*, is a ſalt formed by the union of the tunſtic acid with lime: we apply the name *tungſten* to the metal which appears to be the baſe of the acid, calling this ſpecies of ore *native tunſtate of lime.*

Meſſrs d'Elhuyar of the Biſcayan Society, have diſcovered, that *wolfram*, which was formerly thought to be a poor ore of iron, is a combination of the tunſtic acid with iron and manganeſe. They have obtained a peculiar regulus of this mineral. The wolfram which they have analized was from the tin-mine of Zinwalde. It appears in compreſſed hexahædral priſms; it has the metallic luſtre; its fracture is foliated; and it may be cut with a knife. It contains in the hundred weight 22 parts of black oxide of manganeſe, 12 of oxide of iron, 64 of tunſtic acid, and 2 of quartz. Native tunſtate of lime from Schleckenwelde in Bohemia contains, according to thoſe gentlemen, 68 pounds of tunſtic acid and 30 of lime.

Such

Such are the two known ores of the new ſemi-metal which we call *tangſten.* Meſſrs d'Elhuyar melted one part of wolfram with four parts of carbonate of potaſh; they lixiviated this mixture; the water diſſolved the tunſtate of potaſh; and with the nitric acid they precipitated the tunſtic acid in a yellow powder. This precipitate, when put into a crucible with charcoal, and urged with fire, afforded a metallic button, conſiſting of a number of ſmall friable globules. The following are the properties which they obſerved in this new ſemi-metal: Its ſpecific gravity was conſiderable, but never above 17.6; it appeared to be very infuſible, even more ſo than manganeſe; it was inſoluble in the three ſtrongeſt acids, and even in the nitro-muriatic acid; it entered readily into combination with ſome metals, particularly with iron and ſilver, on the properties of which it produced a ſingular change: it was eaſily reduced to an oxide, and its oxide was yellow, but changed to blue when expoſed to heat, and was inſoluble in acids, but ſoluble in alkalis, and remained diſſolved in water, when triturated with it, in imitation of an emulſion. Though ſome of theſe characteriſtics be analogous with thoſe of molybdena, as Bergman and Scheele had before obſerved in their experiments on the molybdic acid; yet, taken all together, they may be allowed to diſtinguiſh tungſten as a peculiar ſemi-metal. But many more experiments than have yet been made are neceſſary to make us fully acquainted with its properties. Thoſe chemiſts who have turned their views to this object, have made many more experiments on native tunſtate of lime than on the ſemi-metal obtained from it by Meſſrs d'Elhuyar. In order to give a full account of their diſcoveries con-

cerning this mineral, it will be neceſſary for us to inſiſt for ſome time on its properties.

Native tunſtate of lime is ſtill but very ſcarce. It is found in the iron mines of Bitſberg, and in the tin-mines of Schleckenwalde in Bohemia; and moſt of the white tin cryſtals of Sauberg, near Ehrenfriendersdorf are tunſtate of lime. Beſides, on aſſaying the white tin cryſtals preſerved in cabinets, in a way which we ſhall deſcribe, we find among them ſome ſpecimens of this ſubſtance, which were not before ſuſpected to be ſuch.

Tunſtate of lime ſuffers no ſenſible alteration from heat: the action of the blow-pipe makes it decrepitate, and fall into duſt, but does not melt it. A blue flame gives it a faint colour; but nitre diveſts it of that colour.

Boiling water has no power of acting on this metallic ſalt in powder; and it is abſolutely inſoluble. The action of air, earths, the ſalino-terrene ſubſtances, and the cauſtic alkalis on this ſalt, has not yet been attended to.

When the ſulphuric acid is heated and diſtilled on tunſtate of lime, it paſſes without ſuffering any alteration; the reſidue aſſumes a bluiſh colour; when lixiviated in boiling water, it affords a little calcareous ſulphate; which proves that this ſubſtance contains lime, and that the ſulphuric acid decompoſes but a very ſmall part of it.

The weak nitric acid acts on this ſalt with the help of heat, but without producing any diſcernible effervescence. This acid communicates to it a yellow colour, by which it is diſtinguiſhed from real tin ore, and decompoſes

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decompoſes it by abſtracting the lime. About twelve parts of nitric acid in the ſtate of common aquafortis are required to effect the entire decompoſition of one part of calcareous tunſtate. Scheele, in performing this operation, applied the nitric acid, not all at once, but at ſeveral different times. After obſerving the action of three parts of the weak nitric acid on one of this neutral ſalt, he poured upon it two parts of cauſtic ammoniac; the powder which the weak nitric acid turned yellow was rendered white by the alkali: he continued to apply the acid and the alkali ſucceſſively till the calcareous tunſtate was entirely diſſolved. From four ſcruples which he ſubjected to this proceſs he had three grains of a reſidue, which appeared to him to be pure ſiliceous earth. On precipitating the nitric acid employed in this operation by pruſſiate of potaſh, and afterwards by potaſh, he obtained two grains of pruſſiate of iron, or Pruſſian blue, and fifty-three grains of chalk: the ammoniac being combined with the nitric acid afforded an acid precipitate. In this experiment the nitric acid decompoſes the calcareous tunſtate by ſeizing the lime; and the tunſtic acid thus ſeparated is attracted by the amoniac. The ammoniacal ſalt formed by this laſt ſolution is decompoſed by the nitric acid, which has a greater affinity with the ammoniac than the ammoniac has with the tunſtic acid. This laſt acid being much leſs ſoluble than ammoniacal nitrate, is precipitated gradually, as it is left at liberty, in the form of a white powder. That powder muſt be lixiviated with cold diſtilled water, in order that the tunſtic acid may be obtained very pure.

This acid may likewiſe be obtained by a different proceſs, which Scheele employed with the ſame ſucceſs. One part of native calcareous tunſtate in powder with four parts of carbonate of potaſh are melted together in an iron crucible; the maſs is lixiviated with twelve parts of boiling water; nitric acid is poured upon it till it ceaſe to effervesce; it is again melted with four parts of carbonate of potaſh, and again lixiviated with water, and treated with nitric acid till it ceaſe to effervesce: there now remains nothing but a little ſiliceous earth, all the tunſtic ſalt being decompoſed. In fact, during the fuſion, the potaſh is united with the tunſtic acid, forming with it a peculiar neutral ſalt; while the carbonic acid, combining with the lime, converts it into chalk. When the melted maſs is lixiviated, the water diſſolves the tunſtate of potaſh, which is much more ſoluble than chalk, and the chalk remains alone. The nitric acid employed after the water diſſolves the chalk with effervescence, without affecting that portion of the calcareous tunſtate which the four former parts of the alkali have failed to decompoſe. At the ſecond operation, the ſalt having been completely decompoſed by the four former parts of carbonate of potaſh, the nitric acid carries off all the chalk; ſo that by means of the eight parts of fixed alkali and a little aquafortis ſucceſſively applied, the principles of the calcareous tunſtate are entirely ſeparated; its acid is united with the potaſh, and its lime with the nitric acid. On precipitating the calcareous nitrate by potaſh, we learn what quantity of lime was contained in the calca-

reous

reous tunſtate ſubmitted to the proceſs; all that now remains to be done is, to ſeparate the tunſtic acid from the fixed alkali. To effect this, the proceſs described in the former experiment is employed. A ſufficient quantity of nitric acid is poured into the lixivium of the melted mixture of tunſtate of lime with carbonate of potaſh: The lixivium becomes turbid, and thickens; becauſe, as the nitric acid has a greater affinity than the tunſtic with the fixed alkali, the tunſtic acid is precipitated in powder, while the liquor ſtill retains the nitre in ſolution. The precipitate is waſhed with cold water; and the tunſtic acid is then obtained pure in the form of a white powder, as in the former operation. This proceſs is even preferable to the former, as being eaſier, and leſs expenſive.

The muriatic acid acts on calcareous tunſtate in the ſame manner as the nitric acid, decompoſing it with equal energy; and as it communicates to it a yellower colour, Bergman recommends the uſe of it for aſſaying and examining this earthy ſalt.

The tunſtic acid obtained by any one of theſe three proceſſes, appears, as we have already mentioned, in the form of a white powder. When expoſed to the action of the blow-pipe, it becomes yellow, brown, or black; but without melting or being volatilized. It diſſolves in 20 parts of boiling water. The ſolution has an acid taſte, and reddens tincture of turnſole.

The tunſtic acid appears to form with barytes a ſalt which is abſolutely inſoluble in water; with magneſia it forms another ſalt ſcarcely ſoluble.

When

When a ſolution of this acid is poured into lime water, it produces a ſmall portion of precipitate, which may be conſiderably increaſed by applying heat. Scheele thinks this precipitate to be regenerated calcareous tunſtate.

The tunſtic acid, when ſaturated with potaſh, affords a ſalt, which is precipitated in very ſmall cryſtals, the form of which is not certainly known. Scheele ſays nothing of the combination of this acid with ſoda. According to him, it forms with ammoniac a ſalt in ſmall needles. When this ammoniacal tunſtate is expoſed to heat in a retort, the ammoniac eſcapes, and the tunſtic acid remains in a dry yellowiſh powder: the ſame ſalt decompoſes calcareous nitrate to form tunſtate of lime.

When the tunſtic acid is heated with the ſulphuric acid, it aſſumes a bluiſh colour; with the nitric and the muriatic acids it changes to a citron yellow: it communicates a green colour to alkaline ſulphure, and precipitates it. Scheele has not determined to what cauſes theſe changes of colour are owing.

That chemiſt, obſerving that the tunſtic acid is eaſily coloured by combuſtible bodies, as alſo that, like borax, it communicates a blue colour to vitreous fluxes, heated this acid with linſeed oil in a crucible: but he obtained no metal by this proceſs, only the acid was blackened. Bergman, however, concludes from the gravity of this acid being ſo conſiderable, from its colouring inflammable bodies, and from its being liable to precipitation by pruſſiate of potaſh, or Pruſſian alkali, that it is originally of a metallic nature.

We

We have mentioned the proceſs by which Meſſrs d'Elhuyar reduced the tunſtic oxide obtained from wolfram into metallic globules; and the metallic nature of this acid can no longer be conſidered as problematical.

CHAP.

CHAP. XI.

Of Cobalt.

COBALT or cobolt is a ſemi-metal of a white colour, inclining a little to red, of a fine cloſe grain, very brittle, and eaſily reducible to powder by the action of a peſtle. In the hydroſtatic balance, it loſes about an eighth part of its weight. Its ſpecific gravity is, according to Bergman, about 7,700. It cryſtallizes in bundles of needles, arranged one over another.

Cobalt has never been found in nature in a pure and native ſtate; it is almoſt always in calx, and combined with arſenic or its acid, with ſulphur, with iron, &c. The following are the principal ſpecies of cobalt, diverſified by variety of combination, as they have been arranged by Bergman and Mongez.

1. Native

1. Native cobalt united with arſenic. This is a ſolid, grey, ponderous ore, ſomewhat brilliant and granulated in its fracture: it gives fire with ſteel, and becomes black when expoſed to fire. The nitric acid diſſolves it with effervèſcence; with the muriatic acid it forms a ſympathetic ink.

2. Cobalt in the ſtate of an oxide. This ore, which appears to be cobalt oxidated by acids, is commonly of a blackiſh grey colour, ſometimes reſembling lamp-black, generally friable, and pulverulent. It ſtains the fingers; when compact, its fracture exhibits roſe-coloured ſpots. Sometimes it reſembles the ſcoriæ of glaſs; a circumſtance which has led ſome naturaliſts to give it the name of *vitreous cobalt ore*. When this ore is pure it contains no arſenic; but it is often mixed with martial ochre.

3. Cobalt in combination with the acid of arſenic, *flowers of cobalt*, *red*, *roſe-coloured*, or *coloured like peach bloſſoms*. The acid of arſenic which Bergman and M. Mongez have diſcovered in this ſubſtance, gives it its colour. This ore is either in maſſes or in powder, or in a ſtriated efflorèſcence, or in four-ſided priſms, with ſummits of two faces. In fire, it gradually loſes its colour as the arſénic acid is diſengaged.

4. Cobalt ore united with iron and the ſulphuric acid; *ſpecular cobalt ore*. It has been very improperly called *ſulphurcous cobalt*; for it contains no ſulphur, but a little of the ſulphuric acid. This ore is white or grey, very brilliant, and the richeſt of all cobalt ores; it generally gives fire with ſteel.

5. Cobalt

5. Cobalt combined with ſulphur, arſenic, and iron. This mineral bears the name of *white* or *grey cobalt ore;* it is of a whitiſh grey colour, and cryſtallized in complete or truncated cubes, ſo as to form ſolid figures of fourteen, eighteen, or twenty-ſix faces. Its fracture is ſparry and lamellated. On its ſurface it ſometimes exhibits dendrites in leaves reſembling fern: In this ſtate it is called *knit cobalt ore.* White cobalt ore is but ſeldom regularly cryſtallized, but its character may be always diſtinguiſhed by its whitiſh grey colour, its ſpecific gravity which is leſs than that of the preceding ſpecies, and the red efflorescence which almoſt always appears on its ſurface.

In aſſaying cobalt ore, it is firſt pounded and waſhed, and afterwards roaſted to ſeparate the arſenic. The cobalt remains in the ſtate of a lighter or deeper black oxide: this oxide is mixed with three parts of *black flux* and a little marine ſalt: it is melted in a covered crucible with the heat of a forge fire: when it is entirely melted, and the matter perfectly liquid, the crucible is then cooled; as it cools, the matter which it contains is gently ſtirred, in order to precipitate the ſemi-metal, which is accumulated in a button at the bottom of the veſſel. This button ſometimes conſiſts of two metallic matters, its upper part conſiſting of cobalt, and the under part of biſmuth: a ſlight blow with an hammer ſeparates the two.

Modern mineralogiſts, particularly Bergman and Mr Kirwan, propoſe the nitric acid for aſſaying cobalt ores. That acid diſſolves both iron and cobalt. Theſe matters are precipitated with carbonate of ſoda, and the precipitated cobalt is diſſolved by the acetous acid.

Scheffer

Scheffer recommends the melting of cobalt ores with three parts of potaſh and five of powdered glaſs, as a good way of determining their colouring power.

In operations in the great way, cobalt is never obtained in the metallic form. After the cobalt ore is pounded and waſhed, it is next roaſted in a furnace which terminates in a long horizontal flue, ſerving inſtead of a chimney. In this flue the ſublimated oxide of arſenic is condenſed and melted into glaſs, which is ſold in commerce under the improper denomination of *white arſenic*. If the ore happen to contain a little biſmuth, that matter, being very fuſible, falls to the bottom of the furnace, and the cobalt remains in the ſtate of a dark grey oxide which is called *zaffre*. The zaffre in commerce is never pure; it is mixed with a quantity of pulverized flint, amounting to three times its own weight. When this mixture is expoſed to an intenſe heat, it melts into a dark blue glaſs, known under the name of *ſmalt*. This ſmalt is ground to powder in mills, and diluted in water: the firſt portion which ſubſides, being larger grained, is called *coarſe azure*; the water is decanted off while it is ſtill turbid, and affords a ſecond precipitate; it is thus decanted for four times ſucceſſively, and at each time gives a finer precipitate than before; the laſt precipitate is the fineſt of all, and is improperly called *azure of four fires*. This azure is uſed in ſeveral of the arts for communicating a blue colour to metals and glaſſes, &c.

The *zaffre* of commerce, when melted with three times its own weight of black flux, a little tallow, and a little marine ſalt, affords the ſemi-metal improperly known by the regulus of cobalt. It is very difficult to

reduce

reduce zaffre: A great quantity of flux muſt be employed, and care muſt be taken to keep the crucible long enough red hot, in order that the matter may become very fluid and ſettle, and in order too that the ſcoriæ may melt into a blue glaſs: the cobalt is then precipitated and accumulated under the ſcoriæ in a metallic button.

When cobalt is expoſed to fire, it does not melt till it becomes very red. This ſemi-metal is very difficult of fuſion, and appears very fixed in the fire: it is not known even whether it would be poſſible to volatilize it in cloſe veſſels; but we know, that when ſuffered to cool ſlowly, it cryſtallizes into needled priſms, diſpoſed one over another, and bundled together: as M. Mongez has obſerved, they bear a pretty exact reſemblance to a maſs of baſaltes crumbled down into pieces. All that is neceſſary in order to ſucceed in effecting this cryſtallization is, to melt a quantity of cobalt in a crucible till it ſuffer a kind of ebullition, and then, taking the veſſel out of the fire, to ſet it upon one ſide, as ſoon as the ſurface of the ſemi-metal which it contains becomes fixed. This inclination of the veſſel cauſes that part of the metal which is ſtill in a ſtate of fuſion to run off, while that which adheres to the ſides of the veſſel in a kind of gæode, formed by the cooling of the ſurfaces of the cobalt, is fringed with priſmatic cryſtals piled together.

When melted cobalt is expoſed to the air, it is in a ſhort time covered over with a dark and duſky pellicle, which is nothing but an oxide of this ſemi-metal, formed by its combination with the oxigene of the atmoſphere. When a large quantity of oxide of cobalt

is

is wanted, it may be produced more readily by reducing the ſemi-metal to a powder, and expoſing it in a ſhallow veſſel under the muffle of a cupelling furnace, ſtirring it conſtantly to change the ſurfaces. This powder, after being kept red hot for ſome time, loſes its brilliancy, gains an increaſe of weight, and becomes black. The utmoſt force of fire is requiſite to melt this black oxide of cobalt into a deep blue glaſs.

Cobalt is tarniſhed a little in the air, but ſuffers no injury from the attacks of water. This ſemi-metal does not combine with earths, but its oxide unites with them by fuſion to form a very fine blue glaſs, which no intenſity of fire can render volatile. This property of oxide of cobalt renders that ſubſtance very uſeful in painting enamels, porcelain, and pottery.

We know not well in what manner barytes, magneſia, and lime act upon cobalt. Alkali diſſolved in water produces an evident alteration upon it; but the alterations which it ſuffers from the ſeveral alkalis have not yet been ſufficiently attended to.

All the acids diſſolve this ſemi-metal, but with various phænomena, according to the ſtate of the ſemi-metal and the ſtate of the acid.

The ſulphuric acid muſt be concentrated and boiling to diſſolve cobalt. This ſolution is effected in a glaſs phial or a retort. When the acid is almoſt totally evaporated into ſulphurous gas, the reſidue is waſhed; one part of it diſſolves in the water, communicating to it a roſe or a greeniſh colour; this is ſulphate of cobalt: the reſidue is cobalt oxidated by the acid, the oxigene of which has entered into combination with the ſemi-metal. M. Baumé aſſerts, that when the ſulphuric

ſolution

ſolution of cobalt is ſufficiently evaporated and cooled, it affords two ſorts of cryſtals; the one ſort ſmall, white, cubic cryſtals; the other ſpecies, ſquare greeniſh cryſtals, ſix lines in length, and four in breadth. The laſt of theſe he takes to be ſulphate of cobalt: the former owe their formation to ſome other metallic matters in union with the cobalt. The cryſtals of ſulphate of cobalt, which are moſt frequently obtained in the form of ſmall needles, and which M. Sage deſcribes as rhomboidal, tetrahædral priſms, terminating in a dihædral ſummit, with rhombic faces, are liable to decompoſition by fire; the reſidue is oxide of cobalt, not reducibe by itſelf. Barytes, magneſia, lime, and the three alkalis, likewiſe decompoſe this ſalt, and precipitate the cobalt in a roſe-coloured oxide: 100 grains of cobalt diſſolved in ſulphuric acid, afford, when precipitated by pure ſoda, about 140 grains of a precipitate; and when precipitated by carbonate of ſoda, 160 grains. This increaſe of weight is owing to the combination of the oxigene of the ſulphuric acid with the cobalt; in the ſecond inſtance, the carbonic acid combining with the oxide of cobalt likewiſe contributes to the increaſe of its weight. The ſulphuric acid, diluted in water, acts on zaffre, and diſſolving part of it, forms with it ſulphate of cobalt.

The nitric acid diſſolves cobalt with effervеſcence, with the help of a moderate heat: as the oxigenous principle of the acid unites with the cobalt, a quantity of nitreous gas is diſengaged. When the ſolution is ſaturated, its colour is a roſe brown or a bright green: when evaporated by a ſtrong heat, it affords nitrate of cobalt in ſmall bundled needles. This ſalt is very liable

liable to deliquiate: On coals it boils, but does not detonize, and leaves a deep red oxide. It is decompoſed by the ſame ſaline intermediates which decompoſe ſulphate of cobalt. If, on theſe occaſions, more alkali be added than is neceſſary to precipitate the oxide of cobalt, this laſt ſubſtance is then entirely diſſolved, and the precipitate diſappears.

The muriatic acid does not diſſolve cobalt when cold, but with the aſſiſtance of heat it diſſolves a certain portion of it. This acid acts with more vigour on the oxide of the ſemi-metal, forming a reddiſh brown ſolution, which, when heated, becomes green. When this ſolution is evaporated and highly concentrated, it affords muriate of cobalt, which cryſtallizes in ſmall needles, and is very liable to deliquiate. Heat communicates to it at the firſt a green colour, and afterwards decompoſes it.

Aqua regia, or the nitro-muriatic acid, diſſolves cobalt ſomewhat eaſier than the pure muriatic acid, but not with ſuch energy as the nitric acid. This ſolution has been long known by the name of *ſympathetic ink*, and is not viſible till it be heated. Writing performed with this ink, though inviſible when cold, appears when heated of a beautiful ſea-green colour, but diſappears again when the paper becomes cold. This property belongs to the ſolution of oxide of cobalt in the muriatic acid. The nitric acid, which is part of the compoſition of aqua regia, ſerves no other purpoſe but that of helping to diſſolve the cobalt, and to maintain it in ſolution. The green colour which cobalt ink diſplays when heated, and loſes again when it becomes cold, was thought to be owing to a metallic ſalt which

was cryſtallized by heat, but when expoſed to the cold air, attracted ſo much moiſture as diſſolved it, and made it diſappear: but it has ſince been ſhown, that a ſolution of muriate of cobalt in water aſſumes the ſame colour when expoſed to a certain degree of heat.

The boracic acid does not diſſolve cobalt without an intermedium; but when a ſolution of borate of ſoda is mixed with a ſolution of this ſemi-metal in any one of the before-mentioned acids, a double decompoſition is effected; the ſoda combines with the acid in which the metallic oxide was diſſolved, and the boracic acid combining with that oxide forms an almoſt inſoluble neutral ſalt, which is precipitated: on ſeparating the ſupernatant liquor by a filter, the borate of cobalt is obtained ſeparate.

Scarce any of the neutral ſalts are liable to be affected by the action of cobalt. When expoſed to fire with nitre, it is reduced to an oxide. Put into a red-hot crucible a mixture conſiſting of one part of cobalt with two or three of nitre well dried, no detonation will take place; but ſeveral ſmall ſcintillations ſufficiently diſcernible will be ſeen to follow; in conſequence of which, part of the cobalt will be found changed into an oxide of a lighter or deeper red, and often of a greeniſh colour.

This experiment, and all the reſt which have been made on the reciprocal action of nitre and metallic matters, require to be carried farther. Cobalt does not decompoſe ammoniacal muriate. Bucquet performed this experiment with the greateſt care, but did not obtain a particle of ammoniac. This muſt depend on

on the muriatic acid having ſo little power of action on this ſemi-metal.

We know not in what manner hydrogenous gas acts upon cobalt. Sulphur combines with this ſubſtance, but not without great difficulty: but the alkaline ſulphures render this combination eaſier. The product is an artificial ore, with facets of various ſizes, or of a finer or a coarſer grain, and of a white or a yellowiſh colour, according as the proportion of the ſulphur is greater or leſs. M. Baumé, who has given an excellent account of this combination in his Theory and Practice of Chemiſtry (*vol.* 2. *page* 288 *to* 297), obſerves, that it may be decompoſed by the acids, and that fire is not capable of ſeparating all the ſulphur.

Cobalt in its metallic ſtate is of no uſe; but its oxide is uſed to give a blue colour to glaſs, enamel, pottery, and porcelain. It is alſo uſed for making ſympathetic ink.

CHAP. X.

Of Biſmuth

BISMUTH, formerly named *tin glaſs*, is a ſemi-metal of a yellowiſh white colour, very ponderous, and diſpoſed in large plates. It yields a little to the hammer like an elaſtic body, but ſoon breaks into ſmall ſpangles, and is at laſt reduced to powder. In water it loſes one tenth part of its weight. It cryſtallizes into polygon priſms, which are diſpoſed in quadrangular ſolids, reſembling the volutes of Grecian architecture, or perfectly the ſame with thoſe of muriate of ſoda. It has ſcarce any taſte or ſmell.

In nature, biſmuth is generally found in a metallic form. The properties by which it is known are, a ſparkling yellowiſh colour, ſuch a degree of ſoftneſs as renders it liable to be cut with a knife, a lamellated

form,

form, and a ſtrong tendency to fuſion. It is uſually cryſtallized in triangular plates arranged one above another. I have in my poſſeſſion ſome ſpecimens of this ſemi-metal, in which its cryſtals are very regular octohædrons. Its gangue is commonly quartzoſe. It is found at Scala in Neritia, in Dalecarlia, and at Schneeberg in Germany.

A number of modern mineralogiſts doubt the exiſtence of arſenical ore of biſmuth: Some, however, aſſert it to be *chatoyant*, and generally arranged in ſmall, glittering, light grey laminæ: They tell us alſo, that it is almoſt always mixed with native biſmuth and cobalt: the reddiſh efflorescence of the laſt, of which ſubſtances is ſometimes obſervable on the ſurfaces of ſpecimens of biſmuth.

Sulphureous ore of biſmuth, or native ſulphure of biſmuth, which is taken notice of by mineralogiſts, is of a whitiſh grey colour, ſometimes inclining to blue, with facets or needled priſms. The luſtre and colour of this ore are the ſame with thoſe of lead ore or galena: it has almoſt always ſquare facets; but it has never been obſerved in real cubic fragments: it may be cut with a knife: it is very rare, but found at Baſtnaes in Sweden, and at Schneeberg in Saxony.

Cronſtedt ſpeaks likewiſe of an ore of martial biſmuth, which he ſays is found in cuneiform ſcales at Konſberg in Norway.

Laſtly, biſmuth is ſometimes found in the ſtate of an oxide. It is then in the form of a granulated efflorescence, and of a greeniſh, but never of a red colour, on the ſurface of biſmuth ore. Mr Kirwan thinks this oxide to be biſmuth combined with the carbonic

acid. Some mineralogiſts aſſert, that there is a ſulphate of native biſmuth mixed with this calx.

The proceſs for aſſaying biſmuth ore conſiſts in melting it in a crucible by a moderate heat, with the help of a certain quantity of reducing flux. As biſmuth is volatile, it muſt be melted as quickly as poſſible; nay, the beſt way of performing this operation is in cloſe veſſels, as Cramer recommends.

It is equally eaſy to melt biſmuth ore in the great way. Dig a pit in the earth; cover it with billets of wood; ſet fire to the wood, and throw the ore, previouſly broken, upon it while burning; the biſmuth melts and runs into the pit, where it is moulded into an orbicular cake. In ſome places the trunk of a pine is laid on one ſide and hollowed, then covered with wood; the wood is kindled, and the biſmuth thrown upon it while it burns. The ſemi-metal then melts, and runs through the pine into a cavity in the earth. The liquid biſmuth is drawn from this reſervoir, and poured into iron or ingot moulds.

Biſmuth ſuffers no alteration from the contact of light: it is extremely fuſible, and melts long before becoming red hot. When heated in cloſe veſſels it is entirely ſublimated: If left to cool ſlowly, it cryſtallizes in Greek volutes. It is one of thoſe metallic ſubſtances which cryſtallize the moſt readily. M. Brongniart was the firſt chemiſt who ſucceeded in cryſtallizing it.

If biſmuth be held in fuſion, in contact with air, its ſurface is ſoon covered with a pellicle, which changes into a greeniſh grey or brown oxide, called *cinder* or *calx of biſmuth*. By calcining nineteen drachms of biſmuth in a glaſs capſule, M. Baumé obtained twenty drachms

and

and thirty-four grains of oxide. When biſmuth is made red hot, it burns with a faint and ſcarcely diſcernible blue flame. Its oxide evaporates in the form of a yellowiſh ſmoke, which, on coming into contact with cold bodies, is condenſed into duſt of the ſame colour, improperly called *flowers of biſmuth*. What makes this duſt volatilize, is the rapidity with which biſmuth burns; for if it be expoſed by itſelf to fire, it does not ſublimate, but melts into a greeniſh glaſs. Geoffroy, the ſon, obſerved, that towards the end of the operation, this ſublimated oxide of biſmuth is of a beautiful yellow orpiment colour.

The grey or brown, ſublimated or vitreous oxides, are combinations of this ſemi-metal with oxigene, or the baſe of vital air. They cannot be reduced without the addition of a third matter, becauſe the mutual affinity between the two principles of which they are compoſed is very conſiderable. But hydrogenous gas, charcoal, and all organic combuſtible matters which contain both of theſe bodies, decompoſe that oxide, and reduce it to a metal by attracting its oxigene, with which they have a greater affinity than biſmuth has.

M. d'Arcet having expoſed biſmuth in a bowl of unburnt porcelain to the heat of a furnace for burning that ſubſtance, the ſemi-metal ran through a crevice in the crucible, leaving in the veſſel a glaſs of a dirty violet colour, though the biſmuth that ran out of the bowl was yellowiſh. From this fact, and others of the ſame kind, it appears, that there is a difference between metallic glaſſes formed in the air, and glaſſes of the ſame matter which have not been expoſed to air during their formation.

When bismuth is exposed to the air, it is somewhat tarnished, and a little whitish rust is formed on its surface. It suffers no injury from the attacks of water, nor does it combine with earths; but its oxide combines with all earthy matters, promoting their fusion. It communicates a greenish yellow tincture to those glasses, into the composition of which it enters.

We know not in what manner the salino-terrene substances and the alkalis act upon this semi-metal.

Bismuth produces an alteration on the concentrated and boiling sulphuric acid, decomposing it in part, and causing it to exhale sulphureous gas. The mass remaining in the vessel after the decomposition of part of the acid is white. What is in a saline state may be separated by water from that which is pure oxide, and contains scarce any acid. The lixivium on being evaporated affords sulphate of bismuth in small deliquescent needles. This salt may be decomposed by fire, by the salino-terrene substances, by the alkalis, and even by water applied in a large enough quantity.

The nitric acid dissolves bismuth with amazing rapidity, or rather the semi-metal decomposes the acid by robbing it very quickly of part of its oxigene. The mixture becomes very hot, and exhales very thick red vapours. If this combination be effected in a pneumato-chemical machine, a great deal of nitrous gas is obtained; and this is a very speedy and convenient way of obtaining that gas. During the solution, a black powder is precipitated, which Lemery took for bitumen, but Pott thinks to be oxide of bismuth very much calcined. M. Baumé thinks it sulphur; it is possibly charcoal. The nitric solution of bismuth is colourless: when highly saturated

turated, it depoſites cryſtals without evaporation. Evaporation and cooling give a nitrate of biſmuth, concerning the form of which chemiſts are not agreed. M. Baumé ſays, that this ſalt is in large needles pointed at one end. M. Sage deſcribes its cryſtals as tetrahædral priſms, a little compreſſed, and terminating in two obtuſe trihædral pyramids, the ſides of which are a rhombus and two trapezia. By a ſlow evaporation I have obtained it in very large flattened rhomboids, perfectly ſimilar to the calcareous ſpar of Iceland.

Nitrate of biſmuth detonizes with a faint noiſe into reddiſh ſparks; it then melts and ſwells, leaving a greeniſh yellow oxide, which cannot be reduced without the addition of ſome other ſubſtance. When this ſalt is expoſed to the air, it loſes its tranſparency, and the water of its cryſtals eſcapes. When an attempt is made to diſſolve it in water, it becomes white and milky, giving a precipitate of oxide of biſmuth.

The ſame thing happens when the nitric ſolution of biſmuth is poured into water. Moſt part of the oxide of this ſemi-metal is then precipitated in the form of a white powder called *white paint* or *magiſtery of biſmuth*. A ſolution of 100 grains of this metal in the nitric acid affords 113 grains of precipitated oxide, the increaſe of weight being owing to the oxigene abſorbed. To obtain this precipitate very white and fine, a great quantity of water muſt be uſed in the preparation of it. The ladies uſe it for whitening the ſkin; but it unluckily blackens it when it comes into contact with any odorous combuſtible matter; nay, ſcarce any other metallic matter poſſeſſes this property in ſo high a degree. Though the nitrate of biſmuth be moſtly decompoſed

compoſed by the water, yet there ſtill remains a portion of it in ſolution, which cannot be precipitated by any other matter but lime or the alkalis. All ſolutions of biſmuth may be in like manner precipitated by water. We are ſtill ſtrangers to the nature of nitre of biſmuth.

The muriatic acid acts with ſome difficulty on this ſemi-metal: it muſt be concentrated and digeſted for a long time over the biſmuth in order to produce any effect upon it. But this ſolution ſucceeds better when a great quantity of the muriatic acid is diſtilled on the metal; a fœtid odour exhales from this mixture; the reſidue is to be waſhed with water, which carries off a part of the metallic oxide combined with the acid. Muriate of biſmuth cryſtallizes with difficulty: it may be cauſed to ſublime, and it then forms a kind of ſoft fuſible ſalt, improperly called *butter of biſmuth*, which powerfully attracts moiſture from the atmoſphere. Water decompoſes it, cauſing it to precipitate a white oxide.

We know not in what manner the other mineral acids act upon biſmuth.

Common nitre calcines biſmuth, but without any ſenſible detonation. This ſemi-metal does not at all decompoſe ammoniacal muriate; but its oxide ſeparates completely the ammoniac. In this operation a great quantity of ammoniac gas is obtained, and the reſidue is a combination of the metallic oxide with the muriatic acid. As biſmuth acts not on ammoniacal muriate, on account of the muriatic acid having ſo little power of action on this ſemi-metal, it is very remarkable that its oxide ſhould poſſeſs ſuch a property; and the fact

may

may be conſidered as a proof that this ſubſtance is in its nature not very different from ſaline ſubſtances.

Hydrogenous gas alters the colour of biſmuth, giving it a violet tinge.

Sulphur combines with this ſemi-metal by fuſion. From this combination there reſults a ſort of bluiſh grey ſparkling ore, which cryſtallizes into beautiful tetrahædral needles, in their colours reſembling pieces of the moſt beautiful antimony.

Biſmuth is uſed by workers in tin, to communicate a proper hardneſs to that metal. It may be employed inſtead of lead for the cupellation of the perfect metals; becauſe like lead it melts into a glaſs, which is abſorbed by the cupels. Geoffroy the yoûnger obſerved a ſtrong relation to ſubſiſt between this ſemi-metal and lead. We can only gueſs at the effects of biſmuth on the animal œconomy. It is thought, with great appearance of probability, that like thoſe of lead they might be dangerous. This ſemi-metal is even known to produce ſome unfavourable effects when applied externally.

Oxide of biſmuth is uſed under the name of *white paint*, for whitening the ſkin; but the perſon who uſes it muſt be careful to avoid all ſtrong ſmelling matters, particularly ſuch as are fœtid. The vicinity of ſlaughter-houſes, privies, common ſewers, and almoſt any ſtrong ſmelling matter, has ſuch an influence on this oxide that it turns it black. The vapour of alkaline ſulphures, or of eggs, acts with great energy in producing the ſame effect. A very common experiment in natural philoſophy fully proves this fact:—A few characters are written on the firſt leaf of a clean paper book, containing

containing an hundred pages; the laſt leaf is impregnated with a little liquid alkaline ſulphure; in a few moments the hepatic vapour is conveyed by the air between the intermediate leaves to the oppoſite ſide of the book, where it communicates a deep brown colour to the characters which were traced on the firſt page. It has been ſaid, that the ſulphurated or hydrogenous gas penetrates through the paper: but M. Mongé has proved, that it is the air which carries it from leaf to leaf; for when the leaves are glued together the phænomenon does not take place.

CHAP.

CHAP. XI.

Of Nickel.

CRONSTEDT, who conſidered nickel as a peculiar ſemi-metal, firſt made it known to the world in the Acts of the Academy of Stockholm for the year 1751 and 1754. According to him, this ſemi-metal is of a ſparkling colour, inclining to red, eſpecially on its outſide. It is very brittle, and its fracture ſhows it to conſiſt of facets, by which it may be diſtinguiſhed from cobalt. M. Arvidſſon, who, in conjunction with Bergman, publiſhed a theſis on the properties of nickel, which has been tranſlated, and inſerted in the *Journal de Phyſique* for October 1776, obſerves, that nickel obtained by the roaſting and fuſion of its ores, as Cronſtedt directed, is ſo far from being pure, that it contains ſulphur,

phur, arſenic, cobalt, and iron. As Bergman, by a number of ingenious proceſſes, ſeparated moſt of theſe extraneous matters, and obtained a ſpecies of nickel, differing in many of its properties from that deſcribed by Cronſtedt, we ſhall ſpeak of it as the pure metal, after giving the hiſtory of its ores.

Nickel is found in combination with ſulphur and arſenic. Its ores are red-coloured like copper: they are almoſt always covered with a greeniſh grey efflo-reſcence: the Germans call it *kupfer nickel*, or *falſe copper*. That mineral abounds at Freyberg in Saxony; and is generally mixed with grey cobalt ore; but its red colour and greeniſh effloreſcence diſtinguiſh it from this ore, which is grey or black, with a red effloreſcence: its cryſtals are often cubic. Wallerius calls kupfer-nickel, cobalt ore of a red copper colour: he thinks it to be a compound of cobalt with iron and arſenic. Linnæus takes it to be copper mineralized by arſenic. M. Romé de Lille follows Wallerius in ranking it among cobalt ores, and conſiders it as an alloyed cobalt. M. Sage, treating of this ore with ammoniacal muriate, obtained from it iron, copper, and cobalt. He thinks it to be a mixture of theſe three metallic matters with arſenic. A little gold is alſo found in it according to this chemiſt. It is proper to obſerve, that the reſults of this gentleman's experiments on it were different from thoſe obtained by Bergman. His experiments, he tells us, were perſormed on the kupfer-nickels from Biber in Heſſe and Allemont in Dauphiny.

Cronſtedt aſſerts, that nickel may be ſeparated from the metallic matter to which the Germans give the

name

name of *ſpeiſs*, and which is gathered in the crucibles in which ſmalt is melted. M. Monnet thinks that the ſpeiſs manufactured at Gengenback, about fourteen leagues from Straſburgh, is genuine nickel. And as the cobalt ore is uſed at that place in making ſmalt is very pure, he concludes, that the nickel is produced by the cobalt itſelf, as we ſhall afterwards ſee. But M. Baumé obtained nickel from almoſt all the various ores of cobalt by means of alkaline ſulphure. It appears, therefore, that the cobalt ore uſed at Gengenback, contains a portion of nickel which is imperceptible to the eye, on account of its being ſo intimately united with the cobalt.

In order to extract nickel from its ore, it is firſt ſlowly roaſted, to drive off part of the ſulphur and arſenic which it contains. It is gradually changed into a greeniſh oxide; and, according to Bergman and Arvidſſon, the greener this oxide, ſo much the more nickel does it contain. It is next melted with three parts of black flux and muriate of ſoda; and this fuſed matter affords a regulus, ſuch as that which Cronſtedt has deſcribed, but which is far from being pure nickel: the ſcoriæ are brown or blue. A number of chemiſts, ſince Mr Arvidſſon's experiments were communicated to the world, have been induced to conſider this metallic ſubſtance as a natural mixture of iron, cobalt, and arſenic. As to copper, nobody but M. Sage has obtained any of it from kupfer-nickel. M. Monnet thinks that nickel is nothing but cobalt purified of its iron and arſenic. By examining the properties of this ſemimetal, we ſhall underſtand the facts on which theſe ſeveral opinions are founded. We agree with Bergman in

in thinking, that what has occaſioned the miſtakes of chemiſts concerning this ſubſtance, is the extreme difficulty of obtaining nickel, in a ſtate of great purity; a fact which is fully proved in the above-mentioned diſſertation of M. Arvidſſon. It is certain, that when refined to as pure a ſtate as poſſible, it exhibits ſome very ſingular properties; and that hitherto it has neither been ſeparated into ſeveral metallic ſubſtances by analyſis, nor formed by the combination of thoſe metals of which it has been thought to conſiſt; and therefore we have the greateſt reaſon to conſider it as a peculiar ſemi-metal, at leaſt till ſome farther experiments convince us of the contrary.

The ſemi-metal which we obtain by ſimply fuſing roaſted kupfer-nickel, has reddiſh white facets, and is very brittle. It contains a great deal of arſenic, cobalt, and iron. M. Arvidſſon ſubjected it to ſix ſucceſſive calcinations; each of which continued from ſix to fourteen hours. After each of theſe proceſſes, he reduced the ſemi-metal. He obſerved, that when calcined, arſenical vapours, and a white vapour not having the ſame ſmell, were exhaled from the matter in calcination, a mixture of charcoal reduced to powder facilitates the volatilization of the arſenic. The nickel, though its weight was much diminiſhed by thoſe ſix calcinations, ſtill ſmelled of arſenic, and continued to be attracted by the magnet. He afterwards melted it ſix times with lime and borax, and calcined it a ſeventh time, with an addition of charcoal, till ſuch time as it ceaſed to exhale arſenical vapours. This oxide was ferruginous, and clouded with green ſpots. When reduced, it afforded martial ſcoriæ, and a metallic button

ton which was ſtill attracted by the loadſtone. The ſame proceſſes on a variety of ſpecimens from different countries were always attended with the ſame reſults. M. Arvidſſon employed ſulphur, ſulphure of potaſh, the detonation of nitre, as well as ſolution in the nitric acid and ammoniac, with a view to ſeparate the iron from nickel: but by none of theſe means could he effect his purpoſe. From theſe experiments he concluded it to be impoſſible to obtain this ſemi-metal in a ſtate of perfect purity; and likewiſe, that the only way of ſeparating the ſulphur is by repeated calcination; that arſenic adheres to it more obſtinately than ſulphur; that even the arſenic however may be entirely extracted from it by the uſe of powder of charcoal and nitre; that cobalt is ſtill more intimately combined with this ſemi-metal, as the nitre cauſes it to be taken notice of, though nothing in the appearance of the matter indicates its preſence; and that it is impoſſible to free nickel entirely from a mixture of iron: for after being heated in all the above-mentioned ways, it ſometimes attracts the loadſtone more than ever. From all theſe facts, M. Arvidſſon has been induced to think, that nickel is nothing but iron in a peculiar ſtate; and he gives a comparative view of many of the properties of this metal with thoſe of cobalt, iron, and the loadſtone. And from the reſemblance which prevails among theſe ſubſtances, he concludes the three metallic matters to be nothing but different modifications of iron. But what ſeems to have chiefly contributed to make M. Arvidſſon form this concluſion concerning nickel, is its magnetic powers. But we cannot think it fair to confound together ſubſtances, on account merely of their

agreeing in one leading property, ſuch as this; for magnetic powers may poſſibly not be peculiar to iron, but common to it with other metallic ſubſtances. I am therefore of opinion, that though nickel be liable to be attracted by the loadſtone; yet as purified by M. Arvidſſon, it may be allowed to be a peculiar ſemi-metal. For, as I have already mentioned, we can neither extract from it any other metallic ſubſtance, nor imitate its compoſition by any mixture of metals: and beſides, it has properties peculiar to itſelf, which we are now to examine. Mr Kirwan proceeds upon the ſame idea of it in his Mineralogy.

It diſplays no facets, as Cronſtedt has aſſerted; but its fracture is granulated: it is nine times as heavy as water: it has not that brittleneſs which Cronſtedt aſcribed to it; but, on the contrary, its ductility is ſo conſiderable, that Bergman was in doubt whether to rank it among the ſemi-metals or among the metals. It is little eaſier to melt than iron; it is very fixed in its nature. When heated in the air, it is calcined into a green oxide; and the purer the nickel, ſo much the deeper is the colour of the oxide. We know not whether this oxide be fuſible into a glaſs. It is reducible with fluxes and combuſtible matters, which decompoſe it as well as every other metallic oxide. We are equally ignorant of the effects of air and water on nickel. When its oxide is fuſed with vitrifiable matters in making glaſs, it communicates to them an hyacinth colour more or leſs red. The manner in which lime, magneſia, and the three pure alkalis act on nickel, is ſtill unknown.

M. Sage

M. Sage ſays, that when four parts of concentrated ſulphuric acid are diſtilled on one of regulus of kupfer-nickel in powder, it is converted into ſulphureous acid; the reſidue is greyiſh; and when diſſolved in diſtilled water, it becomes of a beautiful green colour. It affords foliated cryſtals of an emerald colour. According to M. Arvidſon, the ſulphuric acid forms with oxide of nickel a green ſalt, in decahædral cryſtals; theſe conſiſt of two quadrangular pyramids, joined and truncated near the baſe.

This oxide diſſolves very readily in the nitric acid. Nitrate of nickel cryſtallizes, according to M. Sage, into rhomboidal cubes; all the other ſolutions of nickel or its oxide in the muriatic acid, or in any of the vegetable acids, are of a lighter or a deeper green. The fixed alkalis ſubſide in a greeniſh white precipitate; after which they are again diſſolved, and the liquor then becomes yellowiſh. When ammoniac is poured into a ſolution of nickel in nitric acid, the mixture aſſumes a beautiful blue colour. The ſame phænomenon takes place when this ſalt is mixed with precipitates of the ſemi-metal produced by the fixed alkalis. As ſolutions of copper exhibit the ſame colour with ammoniac, which colour is even conſidered as a ſure proof of the preſence of the metal wherever it appears, it has been thought, and ſome people are ſtill of opinion, that nickel contains a portion of copper: Yet Cronſtedt in vain attempted by every known means to obtain copper from a ſolution of nickel to which ammoniac had communicated a blue colour; beſides, the ſalt diſſolves copper inſtantaneouſly, but not nickel. From this circumſtance Bergman concludes, that this is an original

property of nickel, and not owing to copper intermixed with it. This chemiſt, after keeping nickel for eight days in aerated water, could not perceive any proofs of its being ſoluble by the carbonic acid.

Nickel detonizes with nitre. This detonation enabled M. Arvidſon to diſtinguiſh the cobalt intermixed with this ſemi-metal, which would otherwiſe have eſcaped his obſervation. After detonation, the nickel is more or leſs oxidated, according as a greater or a leſs quantity of nitre was employed on the occaſion. This neutral ſalt likewiſe enables oxide of nickel to communicate a deeper hyacinth colour to glaſſes; and cauſes the glaſſes impregnated with that oxide to reſume their colour after being deprived of it by fuſion: a circumſtance which happens often enough not only to oxide of nickel, but likewiſe to that of the ſemi-metal, which we are next to examine.

When oxide of nickel is melted with borax, it communicates to it alſo an hyacinthine colour.

It partly decompoſes ammoniacal muriate. The reaſon of M. Sage's obtaining a ferrugineous ſublimate in this experiment, muſt have been his having employed a regulus not ſo pure as that which M. Arvidſon made uſe of. For M. Arvidſon aſſerts, that the ſublimate of ammoniacal muriate, produced by this metal, was white; and when tried with nut-galls, afforded no evidence of its containing iron. A little ammoniac and a little muriatic acid paſſes off: the reſidue, when reduced, proves to be nickel, which is found to have loſt ſomewhat of its magnetic power.

We know not in what manner hydrogenous gas acts upon nickel.

This

This ſemi-metal readily combines with ſulphur by fuſion. It then forms a kind of hard mineral, of a yellow colour, with ſmall ſparkling facets. When expoſed to a ſtrong heat in the air, it crackles and ſcatters around luminous ſparks, like thoſe which fly from red iron hammered in the forge. Cronſtedt, to whom we owe this fact, did not purſue the experiment far enough; Only he obſerved, that this phænomenon cannot take place if the mineral be covered with melted glaſs ſo as to ſeclude it from the contact of air; from which it appears that this effect is owing to the rapid combuſtion of the nickel occaſioned by the ſulphur. The ſame chemiſt informs us, that this ſemi-metal is ſoluble in alkaline ſulphures, producing a compound ſimilar to yellow copper ore. A ſeries of fuſions and calcinations are requiſite to ſeparate nickel from ſulphur.

Nickel combines with arſenic, and adheres to it with great obſtinacy. M. Monnet, who at firſt followed Cronſtedt in thinking nickel a peculiar ſemi-metal, on obſerving that, when united with arſenic, it forms a blue glaſs like that of cobalt, concluded nickel to be nothing but cobalt purified from all mixture of arſenic and iron. Of conſequence, M. Monnet muſt conſider cobalt as well as nickel to be a mixture, not a peculiar metal. Bergman thinks the reaſon of nickel affording a blue colour with the help of arſenic to be, that the cobalt, of which nickel always contains a portion, though the nickel be ſo predominant in the mixture as to render the cobalt imperceptible, is oxidated and ſeparated by the arſenic applied, and then begins to diſplay its properties, and more eſpecially that one by which it is fuſible into a blue glaſs. We have already ſhown, that

repeated calcination with powdered charcoal is requiſite to effect an entire ſeparation between nickel and arſenic.

Nickel combines ſtill more intimately with cobalt than with arſenic; it is exceedingly difficult to ſeparate theſe two ſubſtances. Cobalt often exiſts in combination with nickel, without affording any indication of its preſence: the only ſubſtances that can detect it by fuſion are nitre, borax, and arſenic.

Cronſtedt tells us, that nickel forms with biſmuth a brittle ſcaly regulus. These two ſemi-metallic matters may be ſeparated, imperfectly indeed, by ſolution in the nitric acid, in conſequence of nitrate of biſmuth poſſeſſing the property, which we have taken notice of, of being decompoſable by water.

Nickel has not hitherto been applied to any uſe.

CHAP.

CHAP. XII.

Of Manganeſe.

A MINERAL of a dark grey colour, which ſoils the fingers, and is uſed in glaſs-works for colouring or whitening the glaſs, has long been known under the name of *black magneſia* or *manganeſe*. From its property of acting in this manner on glaſs, the glaſs-makers who uſe it call it *glaſs ſoap*. It was once conſidered by moſt naturaliſts as a poor iron ore, both on account of its colour, and becauſe its ſurface is generally coated with a ferruginous earth. Pott and Cronſtedt, on making an accurate analyſis of this ſubſtance, determined it not to be of a ferruginous nature. Cronſtedt found it to contain a little tin. M. Sage reckons it a zinc ore, and thinks it to be formed by

the combination of zinc and cobalt with the muriatic acid. He adds, from his own observation, that it is sometimes found to contain iron or lead.

The gravity of this mineral, its property of staining glass, and that which it possesses of giving a whitish precipitate when any alkaline prussiate is poured upon any solution of it, led Bergman to suspect, as he informs us in the last paragraph of his Dissertation on Elective Attractions, that it contained a peculiar metallic substance. His suspicions have been fully confirmed by the experiments of M. Gahn, Doctor of medicine, who was one of his pupils, and who, in conjunction with Scheele, discovered the phosphoric acid in bones. That physician was the first who obtained regulus of manganese; very probably by treating the mineral with a reducing flux. No doubt, a very intense heat must be necessary for such an operation; for I once saw M. Brongniart, a very dextrous and experienced chemist, make an ineffectual attempt to reduce this mineral to a metallic button in a furnace in which it was exposed to a very strong heat. I have been assured, that this has been effected in Paris by means of M. Morveau's flux, with which he obtained iron in a button of thoroughly melted metal. But M. de la Peyrouse is of opinion, and I cannot help agreeing with him, that the flux is of no advantage, but rather hurtful in this operation. I have tried this reduction in a very good furnace, constructed in the laboratory of the Veterinarian school at Alfort. I have never yet obtained a well formed button; but I have obtained a considerable quantity of grains, two or three lines in diameter. I repeatedly employed fixed alkali

and

and borax without effect. Each of the metallic grains which I obtained in my ſeveral operations was incloſed in a kind of glaſs or vitreous frit of a deep green colour.

On our principles, this matter is to be regarded as a peculiar ſemi-metal, as it cannot be analyſed, and as, beſides, it diſplays properties which belong to no other metallic ſubſtance. To render our nomenclature uniform, we ſhall call this ſubſtance *manganeſe*.

This ſemi-metal is at preſent much better known than formerly, having been ſo painfully examined by Bergman, Scheele, Gahn, Rinman, d'Engeſtroem, Iſeman, and de la Peyrouſe. Whatever I ſhall advance concerning it, ſhall be founded either on the experiments of theſe chemiſts or on my own. I muſt firſt obſerve, that as it is ſo very difficult to extract the pure ſemi-metal from the ores of manganeſe, the properties of the oxide are therefore much better known than thoſe of the pure metallic ſubſtance. Scheele, one of the moſt ſkilful chemiſts of the preſent age, appears to have been unable to reduce this ſubſtance; for he deſcribes none of the properties which it poſſeſſes in its metallic ſtate.

Ores of manganeſe are diſtinguiſhed by their form, and by their colour, which is grey, brown, or black, and more or leſs brilliant. There are a great many varieties of this ore.

1. Ore of manganeſe, cryſtallized into priſms, tetrahedral, rhomboidal, or ſtriated according to their length, and ſeparate from one another.

2. Ore of manganeſe, cryſtallized in priſms bundled together.

3. Ore

3. Ore of manganeſe, cryſtallized in ſmall needles, diſpoſed in the form of ſtars.

4. Ore of manganeſe, in a black friable efflorescence; which ſoils the fingers like ſoot.

5. Velvet ore of manganeſe. This is an efflorescence in very ſmall needles, of a beautiful black colour, reſembling black velvet.

6. Compact ſhapeleſs ore of manganeſe; of a black grey colour, generally with cavities, but very ponderous. It ſoils the fingers, and is ſometimes found to contain brilliant needles. The Perigueux ſtone belongs to this variety.

7. Sparry manganeſe, found in the iron mines of Klapperud, at Freſko in Dahlland, and deſcribed by M. Rinman.

8. Native manganeſe in metallic globules, found at Sem in the county of Foix by M. de la Peyrouſe. That naturaliſt has deſcribed a great many varieties of manganeſe ore which he found in the ſame place, in the *Journal de Phyſique* for January 1780.

Scheele diſcovered oxide of manganeſe in vegetable aſhes; and he thinks it owing to this ſubſtance, that fixed alkali, when calcined, often aſſumes a green or blue colour. The green colour which potaſh takes when treated with lime, and the roſe colour which I have often obſerved in its combination with acids, are, in his opinion, owing to the metallic oxide. All coals contain a ſmall portion of it.

The fracture of pure manganeſe is of a ſparkling white colour; its texture is granulated like that of cobalt. It is hard, and breaks into pieces, after yielding a little to the hammer. It is more difficult to melt

melt than iron; a circumſtance which made Bergman at firſt conjecture it to have ſome relation to platina.

When manganeſe is heated in the air, it is changed into an oxide, which is at firſt whitiſh, but becomes gradually blackiſh as it is more and more calcined. I have obſerved, that the ſmall grains of manganeſe obtained by the proceſs above-mentioned, are very ſoon altered by the contact of air; they are inſtantly tarniſhed, and aſſume by and by a black or violet colour; ſoon after they fall down into a black duſt reſembling native oxide of manganeſe.

This rapid oxidation of regulus of manganeſe by the contact of air has always appeared to me a very curious and ſingular fact. The globules of this metal are hard, brilliant, and very refractory, and they may be long preſerved in a well ſtopped flaſk, provided their ſurface be unbroken, and covered with a thin cruſt of oxide formed during the fuſion of the ſemi-metal: but if one of theſe globules be broken into three or four pieces, and their fractures expoſed to the air, you in a few minutes ſee their colour change from a white to a purple, a violet, or a roſe colour; and at laſt almoſt to a brown. If theſe fragments be left in a phial containing a certain quantity of air, and gently ſhaken from time to time, at the end of a few months they will be found reduced to a powder almoſt entirely black. This is a kind of metallic pulverization or efflorescence, ſimilar to that of ſaline or pyritous ſubſtances. It proves the exiſtence of a ſtrong mutual attraction between manganeſe and the oxigene of the atmoſphere,

mosphere, and shews the eagerness with which these two substances tend to unite.

The action of manganese on earths and salino-terrene substances has not been examined. The oxide of this semi-metal communicates a brown or violet colour to glass; which colour is susceptible of many modifications, and may be easily destroyed by the action of combustible matters. Nitre restores this brown or violet colour by supplying the manganese with a new quantity of oxigene. This is the reason why the matrasses and retorts of white glass which we use in our laboratories, in extracting vital air from nitre, always acquire a brown or violet colour. Scheele has made a great many ingenious experiments on this colouring of glass by oxide of manganese.

We know not well in what manner the alkalis act upon manganese; but we know that the oxide of this semi-metal combines with ammoniac, and is reduced by it. Bergman observes, that a peculiar gas is disengaged on this occasion, which he thinks to be one of the principles of ammoniac, but says nothing farther concerning it. M. Berthollet has discovered that it is gas azote, and the hydrogene of the ammoniac enters into combination with the oxigene, which it carries off from the manganese, thus reducing it to a white semi-metal. Scheele has given the name of *camelion mineral* to a combination of potash with oxide of manganese, which in warm water takes a beautiful green, and in cold water a red colour. Oxigene and caloric seem to be the chief causes of these phanomena. Perhaps azote, which I consider as the alkalifying, or *alkaligenous* principle, is disengaged from the potash in this operation; and

and is in part the cauſe of theſe ſingular modifications of colour.

The ſulphuric acid is decompoſed by manganeſe, but diſſolves its oxide. This ſolution is coloured and loſes its colour on the addition of a combuſtible matter, ſuch as ſugar or honey; it affords a tranſparent ſulphate of manganeſe, of which the cryſtals are parallelopipeds. This is decompoſed by fire; and it then affords vital air. The alkalis ſeparate from it an oxide of manganeſe, which acquires a beautiful colour on being expoſed to the air.

The nitric acid diſſolves this ſemi-metal, giving out at the time red vapours. Its oxide ſuffers no injury from the attacks of this acid, unleſs the acid be red, or ſome combuſtible body, ſuch as honey or ſugar, be added. The alkalis cauſe theſe ſolutions to yield a white precipitate, ſoluble in acids; which when heated becomes black, and is more completely oxidated. Bergman thinks manganeſe to be one of thoſe metallic ſubſtances which have the moſt affinity with ſalts; for in his table of chemical attractions, he places it near the top of thoſe columns which exhibit the ſeveral affinities of the acids with the various ſubſtances with which they have a tendency to combine.

The muriatic acid alſo diſſolves manganeſe; and when it effects this ſolution cold, the ſemi-metal communicates to it a deep brown colour; when the ſolution is heated, it loſes its colour. Water precipitates it, and alkalis decompoſe it.

We have ſeen under the hiſtory of that acid, that when it is diſtilled on the oxide of this ſemi-metal, the oxide becomes black, and returns nearly to the metallic

metallic ſtate, by giving up part of its oxigene to the muriatic acid, which goes off in the form of oxigenated muriatic acid gas. This acid has a greater affinity than the ſulphuric acid with manganeſe; for when a ſulphuric ſolution of the ſemi-metal is poured into a quantity of muriatic acid, a precipitate is formed, which Bergman, from its property of being ſoluble in alcohol, has decided to be muriate of manganeſe; as that property is known not to belong to ſulphate of the ſame ſemi-metal.

The fluoric acid diſſolves but very little of oxide of manganeſe. The beſt way of combining theſe two ſubſtances is, according to Scheele, to decompoſe ſulphate, nitrate, or muriate of manganeſe by ammoniacal fluate.

The carbonic acid diſſolves a ſmall quantity of manganeſe by digeſtion, with cold; potaſh, with acceſs of air, precipitates the metallic oxide.

Scheele has examined the action of nitre, borax, and ammoniacal muriate on oxide of manganeſe. With the aid of heat, the oxide diſengages the acid from nitre: With potaſh it forms a deep green maſs, which is ſoluble in water, and communicates its own colour to the water in which it is diſſolved. This green colour is owing to the iron contained in the manganeſe; as the iron is precipitated, the ſolution becomes blue. Water and acids precipitate this alkaline ſolution. This is Scheele's *camelion mineral* above mentioned.

When nitrate of potaſh is heated in glaſs veſſels impregnated with manganeſe, it communicates to the glaſs a violet colour; and the more the oxide is calcined

cined, ſo much the deeper is the colour which the glaſs acquires.

When borax is melted with oxide of manganeſe, it acquires a brown or violet colour.

Ammoniacal muriate gives, on being diſtilled with this metallic oxide, pure ammoniac; and the ammoniac is in part decompoſed. Scheele, who firſt obſerved this fact, informs us, that an elaſtic fluid is at the ſame time diſengaged, which he conſiders as one of the principles of ammoniac; but he has not determined the nature of that fluid; and M. Berthollet has ſince diſcovered, that when ammoniac is decompoſed by a metallic oxide, the hydrogene, which is one of the principles of that ſalt, unites with the oxigene of the oxides to form water; while the azote, the other principle of the ammoniac, paſſes into an aeriform or gaſeous ſtate, by entering into combination with caloric.

We know not in what manner hydrogene and ſulphur act upon manganeſe and its oxide. Even the white oxide of arſenic appears to be capable of depriving this acid of a part of its oxigene; for it diſcolours glaſſes which have been ſtained brown by this ſubſtance.

To theſe properties of manganeſe Bergman adds, that it can never be entirely purified from iron; and therefore this new ſemi-metal, like nickel, is unknown as it exiſts in a ſtate of purity. Scheele, who made an accurate analyſis of natural manganeſe, found it to contain iron, lime, barytes, and a little ſiliceous earth.

Oxide

Oxide of manganeſe is employed, under the name of *black magneſia*, in glaſs works, both to purify white glaſs from yellow, green, or blue ſtains, and to give it a violet colour. Probably this phænomenon is owing to the action of the oxigene ſeparated by heat, upon ſubſtances that are coloured.

Native oxide of manganeſe is at preſent employed in the preparation of the oxigenated muriatic acid, and in many other preparations.

This native oxide, when heated by itſelf in a pneumato-chemical machine, affords very pure vital or oxigenous gas. This is the only vital air proper for being adminiſtered to ſick perſons, in the caſes in which vital air is conſidered as a remedy.

The affinity of manganeſe with the principle of combuſtion, is a fact which in many inſtances ſerves to direct the operations of modern chemiſts.

CHAP.

CHAP. XIII.

Of Antimony.

ANTIMONY, *ſtibium*, is a brittle and ponderous ſemi-metal of a ſparkling white colour, and bearing a ſtrong reſemblance to tin or ſilver. It appears to conſiſt of laminæ arranged one over another, and its ſurface exhibits a kind of cryſtals in the form of ſtars or fern leaves. It likewiſe appears in trihædral pyramids, conſiſting of figures like hoppers, ſtanding on their angles one above another; theſe hoppers appear to reſult from the accumulation of quadrangular or octohædral pyramids. In water this ſemi-metal loſes one ſeventh of its weight: it is eaſily reducible to powder. It acts in a very ſenſible manner on the ſtomach; for it is both emetic and purgative.

Native antimony is rarely to be met with: it has been diſcovered by M. Anthony Schwap at Sahlberg in Sweden. M. Schreiber, director of the mines of Allemont in Dauphiny, has found native antimony in thoſe mines. This native antimony is in large plates, and diſplays all the properties of that which is extracted from ore; only it contains one or two hundredth parts of arſenic.

M. Mongez the younger has diſcovered a native oxide of antimony in fine white needles, intermixed with antimony, or bundled together like zeolite. He found this oxide on the native antimony of Chalanges in Dauphiny.

This ſemi-metal is generally combined with ſulphur, and it then forms what has been improperly called antimony, but is in propriety of language an ore or ſulphure of antimony. This mineral is of a blackiſh grey colour, in plates or needles of various ſizes, friable, and either ſcattered about ſingly or joined together in ſome form. It is ſometimes mixed with other metals; and of theſe moſt frequently with lead or iron. It abounds in Hungary and in France in the provinces of Bourbon, Auvergne, and Poitou. Naturaliſts have diſtinguiſhed this ore into a great many varieties, according as its filaments are ſtellated, irregular, parallel, *chatoyant*, &c. When it is mixed with a portion of arſenic, or has been altered by the vapours of alkaline or combuſtible matters, it appears in needles of a deep red colour, bearing a conſiderable reſemblance to beautiful cobalt flowers, but rather more opaque. We may now conſider the ſeveral varieties of this ore.

Varieties.

Varieties.

1. Sulphure of antimony, cryſtallized in hexahædral priſms, terminating in tetrahædral pyramids, obtuſe and ſolitary.
2. Sulphure of antimony in ſtriæ, or conſiſting of large ill-ſhaped needles, lying together in irregular bundles.
3. Sulphure of antimony in ſtellated ſtriæ. Its needles are divergent from a common center.
4. Lamellated ſulphure of antimony; it conſiſts of plates of various ſizes, reſembling the lead ore known by the name of *galena*. This variety is ſometimes ſparkling: when it has this property it is called *ſpecular antimony*.
5. Red ſulphure of antimony. This is a granulous efflorescence on the ſurface of needles of antimony: it is ſometimes cryſtallized in red priſms or needles, the colour of which varies in deepneſs and brightneſs. In this ſtate ſome naturaliſts call ſulphure of antimony *native kermes* or *native golden ſulphur*.

Formerly, ſulphure of antimony was not treated as an ore in order to obtain from it the ſemi-metal: it was only melted to ſeparate the gangue and any other metallic matters which might adhere to it. In that operation two pots are employed; one of them in which the ore is melted, with a number of holes in its bottom; the other ſtanding beneath it to receive the ſulphure of antimony as it melts, is buried in the earth; a fire is made around the upper pot: at firſt a

moderate heat is applied, becauſe the ore is very fuſible, but towards the end of the operation the fire is increaſed, in order that all the ore contained in the mineral may melt and run off. A portion of the other metals, and particularly of the iron which is mixed with this ore, runs off at the ſame time, and theſe metals form a ſtratum of ſcoriæ, on the ſurface of the ſulphure of antimony in the inferior pot. Although the ſulphure of antimony which comes from Hungary be commonly reckoned the pureſt, yet it is certain, that from whatever place this mineral come, it is always ſufficiently pure and proper for the purpoſes to which it is applied, when it needles are regularly formed, and unmixed with ſcoriæ. It is to be obſerved, however, that the ſulphur and the antimony are not always combined in the ſame proportion in this ſulphure; and of conſequence it becomes neceſſary to examine it, whenever it is meant to be employed in the preparation of medicines, as it is much to be wiſhed that the ſtrength of antimonial preparations were uniformly the ſame.

Sulphure of antimony melts very readily, as may be obſerved in the proceſs by which it is ſeparated from its gangue. If urged with fire after being melted in open veſſels, it loſes its ſulphur, which goes off in yellow flowers; the metallic part is alſo reduced with great eaſe to an oxide, and it then flies off in white vapours; but a moderate heat, inſufficient to melt ſulphure of antimony, volatilizes the ſulphur by ſlow degrees; and the metal then combines gradually with the oxigene of the atmoſphere, forming by that combination grey oxide of antimony. This operation cannot be very well effected unleſs the ſulphure be ſo much

much divided as to expoſe a great deal of ſurface to the atmoſphere: it is therefore for this purpoſe reduced to powder, and expoſed to a ſlow fire on a varniſhed earthen pan. A gentle heat muſt at firſt be applied, on account of the mineral being ſo fuſible; but as the operation advances and the ſulphur goes off, the antimony becomes more refractory, and the fire may then be increaſed till it redden the capſule containing the mineral. The operator may conclude that his work goes ſucceſsfully on, when he feels no other ſmell but that of ſulphur exhaling from the roaſted mineral, and obſerves that it does not form into clods; but when the ſulphure becomes clotted, and the ſulphur is decompoſed as it volatilizes (which is indicated by the ſuffocating ſmell of the ſulphureous acid), the heat is then too intenſe, and ought to be diminiſhed.

Though ſulphur appears not to be very cloſely combined with antimony in its ore, yet it is impoſſible to drive it entirely off by roaſting. The grey oxide of antimony prepared by the above proceſs always retains a pretty conſiderable quantity of ſulphur, even though the ſemi-metal have been calcined till it loſt its metallic properties.

When the grey oxide of antimony is, by itſelf, urged with fire, it melts into a glaſs of a reddiſh brown or an hyacinth colour. This glaſs is more or leſs fuſible, and more or leſs tranſparent, according as the mineral from which it is formed has been more or leſs calcined. If it contain but a little ſulphur and a great deal of oxigene, the glaſs which it affords is tranſparent and ſcarce fuſible: this is *glaſs of antimony*, properly ſo called, or vitreous oxide of ſulphurated anti-

mony. If the oxide contain a large proportion of ſulphur, and be leſs remote from the metallic character, it produces a glaſs which is more fuſible and opaque; this glaſs is called *liver of antimony*, becauſe it is of a dark red colour, like that of the liver of animals. When oxide of antimony has been ſo completely calcined that it will ſcarce melt, a little ſulphur or ſulphure of antimony caſt into the crucible in which it is expoſed to heat, will cauſe it to melt in an inſtant.

When grey or vitreous oxide of antimony is heated in a crucible, with an equal quantity of black flux and a little black ſoap or oil, it is reduced to pure antimony. The black flux ſerves two purpoſes in this operation: the alkali which it contains combines with the ſulphur, of which fire alone could not free the oxide, and the carbonaceous matter contributes to the reduction of the metallic oxide. Antimony is thus prepared in the great way in commerce; it is then called *regulus of antimony*. The ſemi-metal is moulded into flat orbicular cakes, which exhibit on their ſurface a cryſtallization reſembling fern leaves.

Antimony is liable to no alteration from the contact of light. It does not melt till it be red hot; and on being expoſed to an intenſe heat in cloſe veſſels, it is entirely volatilized without ſuffering decompoſition. If it be left to cool ſlowly after being melted, and the fluid part be poured off after the ſurface is conſolidated, what remains will be found cryſtallized in pyramids or hoppers, as we have mentioned above.

The ſemi-metal, when melted in open veſſels, is very quickly oxidated. A thick white ſmoke riſes from it, and is precipitated at the ſurface of the melted metal,

or fixes on the lid of the crucible in the form of ſmall white needles: this is a ſublimated metallic oxide which has been improperly called *ſilver flowers of regulus of antimony*, or *ſnow of antimony*. In preparing a certain quantity of this matter, a crucible is placed horizontally in a furnace, ſo that its rim is exactly fitted to the mouth of the furnace to which it is luted with clay. The antimony is put into this crucible; a degree of heat is applied ſufficient to melt the ſemi-metal and raiſe it in ſmoke: the ſmoke is received into a ſecond crucible covering the firſt; and it is there condenſed into very ſlender, white, and brilliant needles, which appear to be four-ſided priſms.

The white ſublimated oxide of antimony, not only volatilizes during the burning of the ſemi-metal; but, when urged with fire, it is ſublimated even by itſelf. This oxide may be likewiſe melted into an orange-coloured glaſs: this glaſs is paler and more tranſparent than that which is formed with the grey ſulphurated oxide of antimony; but it is alſo much more difficult to melt.

Antimony ſuffers no alteration from combuſtible matters, but they decompoſe the oxide, reſtoring it to the ſtate of regulus. As oxide of antimony is almoſt always very completely oxidated or highly ſaturated with oxigene, it is exceedingly difficult to make it repaſs into the metallic ſtate; and as it is alſo a very volatile ſubſtance, it becomes neceſſary to perform this reduction in cloſe veſſels. The white ſublimated oxide appears to be ſoluble in water, and to have acquired by ſublimation ſome ſaline properties. Rouelle was the firſt who made this obſervation on flowers of antimony.

Some other metallic oxides, particularly thoſe of arſenic, molybdena, and tungſten, become ſaline and acid when ſaturated with oxigene; and perhaps the ſame property may be, one day or other, diſcovered to belong to oxide of antimony.

Antimony is but very little altered by air; its ſurface is only a little tarniſhed. It is not ſoluble in water; yet ſome phyſicians ſuſpect that it communicates to this fluid a very diſcernible emetic quality. White oxide of antimony, when diſſolved in water, communicates to that fluid emetic properties. This power of action, together with its volatility and ſolubility, gives this oxide a kind of analogy with oxide of arſenic. Many mineralogiſts have been of opinion that the ore of antimony is never without arſenic. It is certain, that both the ore and the regulus, when reduced to powder and thrown upon coals, exhale an odour which is eaſily diſcerned to be arſenical; and when a perſon is for ſome time expoſed to that vapour, he feels it to act upon him as a cathartic and a weak poiſon; as I myſelf have ſeveral times experienced in my laboratory.

Earthy ſubſtances have no power of action on antimony: its oxide enters with eaſe into the compoſition of glaſſes, communicating to them an orange colour of a nearer or a more remote reſemblance to the hyacinth.

We are unacquainted with the manner in which the ſalino-terreous ſubſtances and the alkalis act upon antimony: we know more concerning the influence of the acids on this ſemi-metal.

The ſulphuric acid, when boiled ſlowly over this regulus, is itſelf decompoſed, and oxidates a part of the ſemi-metal; a good deal of ſulphureous gas is exhaled from

from it, and towards the end of the operation there is a little ſulphur ſublimated. The maſs which remains, after the decompoſition of the acid, is a compound, conſiſting of a good deal of metallic oxide with a ſmall portion of the ſemi-metal, combined with the acid, ſo as to form ſulphate of antimony. The ſaline part is ſeparated by means of diſtilled water. This ſalt, when evaporated with a ſtrong heat, is very deliqueſcent, and not ſuſceptible of cryſtallization; fire eaſily decompoſes it; pure water, the ſalino-terreous ſubſtances, and the alkalis, likewiſe ſeparate its principles. It is very difficult to reduce oxide of antimony that has been formed and precipitated by the ſulphuric acid.

The nitric acid attracts antimony with eagerneſs: the acid is decompoſed, oxidates moſt of the metal, and diſſolves a part of it. This ſolution takes place readily enough when the ſubſtances are cold:—the ſalt produced, after being ſeparated by lixivation from the part which is oxidated, gives by evaporation nitrate of antimony, which is very liable to deliquiate, and is decompoſed by fire, and by the ſame intermedia which decompoſe ſulphate of antimony. The oxide of antimony formed by the nitric acid is very white: it is likewiſe one of the moſt refractory and the moſt difficult to reduce of all the metallic oxides.

The muriatic acid appears to have more difficulty than any of the other acids in acting on antimony. Yet it diſſolves the ſemi-metal with the help of a long digeſtion; but does not oxidate it ſo much as the ſulphuric and the nitric acids. I have obſerved, that when the acid remains for a long time over antimony in powder, it acts ſlowly on the ſemi-metal, diſſolving

a good

a good quantity of it. The muriate of antimony obtained in ſmall needles by a violent evaporation, is very liable to deliquiate. It melts in the fire; it volatilizes, and is decompoſed by diſtilled water like the ſublimated muriate of antimony, called *butter of antimony*, which we will ſoon have occaſion to conſider; and which differs but very little from this compound. M. Monnet, who has given a good deſcription of this combination effected by a pretty intenſe heat, obſerves, that there is a very conſiderable difference between that which is prepared with the oxide and that made up with the ſemi-metal; the former being of a more fixed nature, and cryſtallizing in laminæ, like ſulphate of lime and the boracic acid. That ſalt is beſides decompoſable by water. We have had occaſion to obſerve, that in ſolutions of antimony by the muriatic acid effected by diſtillation, there is always a portion of ſalt which is never volatilized by the action of fire, but reſembles the ſalt mentioned by M. Monnet. This is owing to its having been highly oxidated by the acid. This obſervation may be in like manner applied to almoſt all ſolutions of metals, which are found to exiſt in many different ſtates, according as the metal which they contain is more or leſs completely calcined or oxigenated. M. Monnet affirms as a certain and invariable fact, that 12 grains of oxide of antimony are ſufficient to ſaturate half an ounce of common muriatic acid; the preciſe ſtrength of which he does not determine. Bergman ſays, that the muriatic acid has a greater affinity than any of the other acids with antimony. The oxigenated muriatic acid oxidates antimony with the greateſt eaſe.

Aqua

Aqua regia, or the nitro-muriatic acid, diſſolves this metal with more energy than either of the two acids of which it is made up; for the muriatic acid has in this compound acquired new activity, in conſequence of being united with the oxigene ſeparated from the nitric acid. Nitro-muriate of antimony is very deliqueſcent, and may be decompoſed like the other ſaline combinations of this ſemi-metal.

Sulphure of antimony, or the natural combination of ſulphur with the ſemi-metal, is generally more entirely diſſolved, but leſs completely oxidated, by acids than the ſemi-metal. Sulphur appears to defend antimony in ſome meaſure from the attacks of thoſe ſaline ſubſtances. The nitro-muriatic acid acts gently on this mineral: it may be advantageouſly employed to ſeparate the ſulphur which it precipitates in the form of a white powder. M. Baumé recommends for this operation *aqua-regia*, conſiſting of four parts of the nitric with one of the muriatic acid: but he has not mentioned the preciſe degrees of ſtrength which the acids ought to have. When this mixed acid ceaſes to act on ſulphure of antimony on which it has been poured, the ſolution is then filtrated, and the ſulphur remains on the filter. By weighing this ſulphur, the reſpective quantities of ſulphur and antimony contained in the ore analized come to be known. But it is to be obſerved, that this ſulphur always contains a ſmall portion of oxide of antimony; and therefore this experiment cannot be thought very accurate, at leaſt if the oxide be not previouſly purified by acids from the ſulphur intermixed with it.

The

The muriatic acid employed to diſſolve ſulphure of antimony, affords by the ſolution a little *kermes*, which ſhews that the fluid is decompoſed.

This ſemi-metal decompoſes many neutral ſalts. M. Monnet, in his Treatiſe on the Solution of Metals, deſcribes an operation, ſhowing that antimony decompoſes ſulphate of potaſh. He melted in a crucible a mixture conſiſting of one ounce of that ſalt with half an ounce of this ſemi-metal. The product was a yellow, vitriform maſs, extremely cauſtic, being nothing elſe but antimoniated ſulphure of potaſh. When this maſs was diluted in hot water, and afterwards cooled, it afforded a reddiſh ſulphurated oxide of antimony, or genuine *kermes*. On this occaſion, according to the new doctrine, the ſemi-metal, by depriving the ſulphuric acid of its oxigene, cauſes it to paſs into the ſtate of ſulphur. I have made a ſeries of experiments, which prove that many other metallic ſubſtances decompoſe ſulphuric ſalts, as I ſhall ſhow in the following chapters.

Antimony decompoſes nitrate of potaſh with great rapidity. If equal parts of this ſemi-metal and nitre in powder be thrown into a red-hot crucible, the ſalt gives a ſmart detonation, and burns the metal by means of the oxigene which it ſupplies. After the operation, the fixed alkaline baſe of the nitre, and the antimony in the ſtate of a white oxide are found in the crucible.

This oxide has received the name of *diaphoretic antimony*. We call it *oxide of antimony by nitre*. Not antimony, but its ore, or native ſulphure of antimony, is moſt frequently uſed for this preparation. Only a larger quantity of nitre muſt then be added; ſuch as three parts of the ſalt to one of the mineral, in order that not only

only the metal, but likewiſe the ſulphur united with it may be burnt. The reaſon why the ore is preferred to the ſemi-metal is, that the ſulphur renders the detonation of the nitre more rapid and more complete, and greatly facilitates the combuſtion of the antimony.

The matter remaining in the crucible after the detonation, conſiſts of oxide of antimony, combined in part with the fixed alkali of the nitre, and with ſo much of the nitre which has eſcaped detonation; it contains likewiſe a little ſulphate of potaſh, formed by the union of the acid of the ſulphur, with the fixed alkali of the nitre. This compound has been named *ſolvent of Rotrou*, or *unwaſhed diaphoretic antimony*. This matter is caſt into hot water, and diluted by the ſolution of the ſaline part, while the metallic oxide remains ſuſpended in the water. The turbid water is decanted off, and the fixed white oxide ſuffered to ſubſide. After paſſing thro' this proceſs, it receives the name of *waſhed diaphoretic antimony*. It is moulded into little balls, and then carefully dried. The ſaline part of the mixture remains diſſolved in the ſupernatant water, as well as a part of the metallic oxide, ſtill in union with the nitrated potaſh. If an acid be poured on this liquor, it combines with the acid, and the oxide of antimony is precipitated. This oxide is improperly called *ceruſe of antimony*, or *materia perlata* of Kerkringius. The liquor that remains after the precipitation of the *materia perlata* contains a little nitre which has eſcaped detonation, a ſmall portion of ſulphate of potaſh produced by the detonation, and the neutral ſalt newly formed by the combination of the acid with the alkali, by which the metallic oxide was held

held in ſolution. Though the nature of this ſalt varies according as one or another of the acids is employed, yet it has been called, but very improperly, *Stahl's antimoniated nitre.* It very often contains not a grain of nitre; for the ſulphuric or the muriatic acid may be with equal advantage employed to precipitate the oxide of antimony. And when the oxide is properly precipitated, no part of it remains combined with the neutral ſalt.

Oxide of antimony obtained by nitre may be melted, as well as the before-mentioned oxides of the ſemi-metal, into a glaſs: but being very much calcined, it is no eaſy taſk to melt it. For the ſame reaſon, it is equally difficult to reduce this oxide to a metallic ſtate, even more difficult than to reduce oxide of antimony that has been oxidated and ſublimated by fire. It is not yet known whether this oxide be ſoluble in water and acids.

Antimony appears to be capable of decompoſing muriate of ſoda; for if a mixture of the two ſubſtances be heated in a retort, agreeably to what has been remarked by M. Monnet, ſublimated muriate of antimony paſſes into the receiver. He does not deſcribe the reſidue.

This ſemi-metal, according to Bucquet, has ſcarce any power of decompoſing ammoniacal muriate; no *butter* or ſublimated muriate can be obtained by this decompoſition, agreeably to what has been aſſerted by Juncker.

All combuſtible matters act more or leſs on this ſemi-metal. Hydrogenous gas alters its ſurface and colour. It acts with ſtill more energy on ſolutions of antimony.

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On my cauſing a quantity of that gas obtained from iron and the aqueous ſulphuric acid to paſs into a nitro-muriatic ſolution of antimony, the ſolution became inſtantly turbid, and depoſited a matter of an orange yellow colour, reſembling *golden ſulphur*, but never reſembling real *kermes*. White oxide of antimony, when expoſed in the ſame manner to hydrogenous gas, both dry and diluted in water, ſuffered no alteration.

Sulphur combines readily with antimony to form an artificial ore, which is an exact imitation of native ſulphure of antimony. To effect this combination, equal parts of ſulphur and antimony are to be haſtily melted together in a crucible; and the product is a needled mineral of a dark grey colour, which never contains ſo much as half its weight of ſulphur, unleſs the two ſubſtances have been mixed together in the proportion of a part and an half of ſulphur to a part of the ſemimetal. I have even obſerved, on melting an ounce of antimony in a retort with an ounce of ſulphur, the product to be ten drams of ſulphure of antimony, and to contain of conſequence only two drams of ſulphur; while the reſt of that combuſtible ſubſtance had ſo ſwollen by fuſion as to make its way into the receiver. No more therefore than one part of ſulphur is requiſite to communicate to four parts of antimony the character of ſulphurated ore of antimony. And in pharmacy therefore, it is very neceſſary to examine in what proportion the two ſubſtances are united in any quantity of this ore uſed in preparing medicines, in order to eſtimate the effects which it may produce in combination with other ſubſtances.

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The alkaline ſulphures, or *livers of ſulphur*, entirely diſſolve antimony, forming in conſequence of the ſolution a yelloviſh matter, from which a precipitate of antimoniated ſulphur may be obtained by an acid, which inſtantaneouſly communicates to it an orange colour. *Hepatic* gas, or ſulphurated hydrogene, acts on ſolutions of this ſemi-metal preciſely in the ſame manner as hydrogenous gas.

Antimony combines with arſenic and with biſmuth; but theſe metallic mixtures have not yet been examined with ſufficient care.

Such are the principal properties of this ſemi-metal: But it is neceſſary to examine in a particular manner its ore, which has improperly received the name of *antimony*. As this mineral is moſt commonly uſed, and in a great many very valuable pharmaceutical preparations, it is natural to think that its properties muſt be much better known than thoſe of the ſemi-metal which it contains. The alchemiſts, who paid much attention to this ſubſtance, were the diſcoverers of ſome part of that knowledge which we at preſent poſſeſs concerning its properties: And indeed no ſubſtance has undergone more experiments than have been made on ſulphure of antimony. We have already ſeen, that with the help of heat, a portion of ſulphur may be ſeparated from it; and that from this operation there reſults a grey oxide, fuſible into *glaſs* or *liver* of antimony, according as the calcination is more or leſs completely effected. But roaſting and combuſtion by nitre are not the only means of ſeparating from antimony the ſulphur which it contains. This ſeparation may be likewiſe effected by preſenting to the mineral ſome ſubſtance having a greater

greater affinity with the metal than the metal has with the ſulphur, or having a greater affinity with the ſulphur than it has with the metal.

We have an inſtance of the firſt of theſe decompoſitions when acids are applied to crude ſulphure of antimony. Thoſe ſalts, eſpecially the nitro-muriatic acid, diſſolve the ſemi-metal, and ſeparate the ſulphur, cauſing it to ſwim on the ſurface of the ſolution. The metal even appears to diſſolve eaſier and more completely in ſulphure of antimony than when it is pure; as we have already remarked. Iron, and ſome other metallic ſubſtances attract the ſulphur from this regulus.

Nitre is ſucceſsfully employed with this ſulphure in the preparation of a number of medicines of ſome conſequence. We have already ſeen, that when one part of this ore is made to detonize with three parts of nitre, both the ſulphur and the metal are burnt, and what remains is a white metallic oxide mixed with alkali. When equal parts of nitre and ſulphure of antimony are cauſed to detonize together, the detonation is leſs briſk, on account of the proportion of the nitre being leſs. This mixture therefore requires to be poured by ſpoonfuls into a red-hot crucible; whereas that which is intended to form white oxide, or *diaphoretic antimony*, needs only to be kindled once, when it immediately detonates, till the whole be reduced to a white maſs. When the detonation of this mixture, conſiſting of equal parts of nitre and ſulphure of antimony is effected, the whole maſs is urged with heat till it melt: and inſtead of *diaphoretic antimony*, the crucible is found to contain an opaque brown

maſs, ſparkling, extremely brittle,—in a word, a brown opaque *glaſs of antimony* covered with ſcoriæ. It is eaſy to obſerve, that in this operation, the quantity of the nitre is not ſufficient to burn all the ſulphur. That portion of the ſulphur which eſcapes combuſtion cauſes the oxide of antimony to melt together with itſelf. When this mixture is not urged with fire till it be brought into a ſtate of fuſion, the product obtained is nothing but a vitreous ſcoria, which was formerly called *Rulland's falſe liver of antimony.* This matter, when reduced to powder and waſhed in water, forms *crocus metallorum;* which is nothing but vitreous oxide of antimony pulverized, and ſeparated from the ſaline matters, with which it is mixed in conſequence of the detonation of the nitre.

There are two other preparations ſimilar to the foregoing, and, as well as it, true ſulphurated glaſſes of antimony. The one is the ruby of antimony or *magneſia opalina;* which is obtained by melting in a crucible equal parts of decrepitated muriate of ſoda, nitre, and ſulphure of antimony. The melting of this mixture, which is not preceded by detonation, affords a vitreous maſs of a light brown colour, very brilliant, and covered over with white ſcoriæ. The other very improperly called *medicinal regulus*, is prepared by melting a mixture conſiſting of fifteen ounces of ſulphure of antimony, twelve ounces of decrepitated muriate of ſoda, and three ounces of tartar. From the fuſion of this mixture there reſults a gliſtering black glaſs very opaque and very denſe, and of which the appearance does not, in the ſmalleſt degree, reſemble that of metals. Theſe two compounds, which differ in ſome external properties from true *liver of antimony*, doubtleſs owe thoſe properties

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by which they differ from it to the marine ſalt uſed in preparing them; but its effects on this mineral have not yet been exactly eſtimated.

To extract antimony from its ore in the ſmall way, no more nitre muſt be employed but what is requiſite to burn the ſulphur; and ſome other matter which may promote the reduction of that part of the metal, which is reduced to an oxide during the operation, muſt be likewiſe added to the mixture. For that end, take eight ounces of ſulphure of antimony in powder, ſix ounces of tartar, and three ounces of nitre; mix theſe matters well together, and put the mixture by ſpoonfuls into a red hot crucible: the nitre will detonize with the tartar and the ſulphure of antimony, forming black flux, and the antimony will be at the ſame time melted. When the matter is ſufficiently melted, let it be poured into an iron cone greaſed and made hot: let the cone be ſtruck with a few blows while the mixture is poured in; let the whole be ſuffered to cool, and the regulus will be found in a pyramidal form at the bottom of this veſſel. This ſemi-metal is covered over with reddiſh black ſcoriæ, which readily attract the moiſture of the atmoſphere. When the upper ſurface of the regulus is convex, and exhibits a regular ſtar, it may be conſidered as pure. This ſtar, which ſuggeſted to the imaginations of the alchemiſts the moſt extravagant notions, depends on the manner in which the ſemi-metal cryſtallizes as it cools. The outer edges cool firſt; and the fluid matter being then driven towards the centre, produces this cryſtallization, which never takes place but on ſmall maſſes of antimony; for in large cakes of this ſemi-metal, as the fluid matter undulates round

ſeveral centres, inſtead of a ſtar, the cryſtallization exhibits fern-leaves under different angles. Reaumur has ſhewn that ſudden cooling prevents this ſtellated cryſtallization from taking place; and that if even one ſide of the cone be ſuddenly cooled, only half a ſtar is obtained *. The quantity of metal obtained by this proceſs is not equal to an half of the ſulphure of antimony employed on the occaſion, although the mineral generally contains more regulus than ſulphur, becauſe part of the ſemi-metal enters into combination with the ſaline matters which form the ſcoriæ.

Theſe ſcoriæ are compound bodies, conſiſting of a great many principles. They are found to contain the fixed alkali of the nitre and the tartar, combined with the ſulphur of the antimony in the ſtate of alkaline ſulphure. This ſulphure holds in ſolution a portion of oxide of antimony, and is mixed with a little ſulphate of potaſh, formed in conſequence of the ſulphuric acid produced by the combuſtion of the ſulphur having combined with part of the alkali which belonged to the nitre. Laſtly, theſe ſcoriæ contain likewiſe a carbonaceous matter which they owe to the tartar. On boiling them in a large quantity of water, and filtrating the boiling liquor, this carbonaceous matter is left on the filter. This ſolution is clear while it remains warm, but as ſoon as it cools, it becomes turbid, and depoſites a reddiſh

* There is doubtleſs ſome analogy between the way in which metallic buttons cryſtallize on their ſurface and the form which they aſſume, when by a well conducted cooling, and by ſeparating the fluid from the fixed part, art diſpoſes them in ſeparate cryſtals. This has engaged the Abbé Mongez's attention in his reſearches concerning the cryſtallization of metals. A.

a reddiſh matter, which is at preſent thought to be antimoniated ſulphure of potaſh. This precipitate is called *kermes mineral* by the dry way. When the liquor ceaſes to depoſite a precipitate, it then affords by evaporation a matter not ſo deep coloured as *kermes*, which is a real antimoniated ſulphure of potaſh. It affords likewiſe ſulphate of potaſh. If, inſtead of evaporating the liquor, you pour an acid into it, it gives a precipitate of ſulphurated oxide of antimony of an orange yellow colour; which was formerly called *golden ſilver of antimony*, and ſeems to differ but little from *kermes*.

If a quantity of ſulphure of antimony reduced to powder be boiled for a few moments in water containing carbonate of potaſh or of ſoda, either of theſe effervescent alkalis diſſolves the ſulphur, and forms by that means an alkaline ſulphure, which holds a part of the oxide of antimony in ſolution: this boiling liquor is filtered; and by cooling it depoſites as a precipitate that portion which it contains of *kermes* or red ſulphurated oxide of antimony. When this liquor is cooled and filtered, a new precipitate of orange coloured ſulphurated oxide of antimony may be obtained from it by acids. If an alkaline lixivium be boiled anew over this reſidue, *kermes* may be again obtained. But this *kermes* is of a paler colour than that which was at firſt obtained; and the oftener the operation is repeated, the more does the precipitate differ in nature from genuine *kermes*. The alkali appears to diſſolve more of the ſulphur than of the oxide of antimony; and ſulphure of antimony ſhould not therefore be boiled oftener than

once or twice in the alkali. This operation is generally called the preparation of *kermes* by the humid way.

This name was given it by a Carthuſian friar, named *Simon;* doubtleſs, becauſe its colour reſembles that of the animal called *kermes**, which is uſed in dyeing. Mineral kermes has been alſo called *Carthuſian powder*, becauſe it was at firſt prepared in a laboratory belonging to that order. Glauber appears intitled to the merit of being the diſcoverer of this medicine; for he prepared it with ſulphure of antimony, and liquor of nitre fixed by coal. But he has deſcribed his proceſs in an unintelligible language; nay almoſt in alchemical ſymbols. Lemery, who laboured much in inveſtigating the nature and the combinations of antimony, and who has given, under a different name, a preparation ſimilar to *kermes*, may be regarded as being properly the inventor of this compoſition. It was, however, offered to the world as an entirely new preparation many years after the publication of that chemiſt's work; and it owes its celebrity to the ſurpriſing cures which it effected when firſt adminiſtered by the Carthuſian friar Simon. He received it from a ſurgeon of the

* The animal *kermes*, or *ſcarlet grain* uſed in dyeing, is the ſkin of a female inſect, which fixes on the holm or ilex, and gradually increaſes its bulk into the form of a cap. It loſes the annular form which diſtinguiſhes thoſe animals. Under this cap are contained the eggs of the inſect. The young inſects iſſuing from the eggs pierce through the ſhell; and the females being without wings, fix upon the leaves of trees and die there, after being impregnated by the males who are winged. The cochineal inſect is another ſpecies, in nature ſimilar to this; as we ſhall ſhow when we come to ſpeak of the animal kingdom. A.

the name of *Ligerie*, who was not himſelf the inventor of it. Ligerie ſaid that he had it from M. Chaſtenay, the King's Lieutenant at Landau, to whom it was ſaid to have been communicated by an apothecary who pretended to be a diſciple of Glauber's. Dodart, at that time firſt phyſician to the king, applied to Ligerie to publiſh his receipt for making *kermes*; and it was accordingly communicated to the world by that ſurgeon in the year 1720. Lemery, the ſon, in the Memoirs of the Academy, aſſerted his father's right to the honour of this diſcovery: and with the more reaſon, becauſe moſt apothecaries, in preparing *kermes*, ſtill follow the proceſs of that ſkilful chemiſt.

Ligerie's proceſs conſiſts in boiling a pint of rain water for two hours, with four ounces of liquor of nitre fixed by coals, and a pound of ſulphure of antimony broken into ſmall pieces; filtrating the boiling liquor; boiling the ſame ore with three ounces of new liquor of fixed nitre diluted in a pint of rain water; and, laſtly, ſubjecting the ſecond reſidue to a third boiling, with the ſame lixivium as before, namely, adding to it two ounces of liquor of fixed nitre, with a pint of rain water. The liquor is then filtered, and ſet aſide till it depoſite the *kermes*; it is then waſhed till it become inſipid, dried, and after ſpirit of wine has been burnt over it, reduced to powder. This proceſs is tedious, and affords but very little *kermes*; for all that is obtained is at moſt but two or three drams to the pound of ſulphure of antimony. It is likewiſe very troubleſome, on account of ſo much boiling and evaporation of water. Laſtly, Three-fourths of the ore of antimony are loſt in this proceſs; becauſe the quantity of the

alkali employed is ſo ſmall in proportion to that of the mineral.

M. Baumé, who follows Lemery, gives two proceſſes for preparing in a very ſimple manner, and in a very ſhort time, a great quantity of kermes, or red ſulphurated oxide of antimony; the dry, and the humid way. In the firſt, a mixture conſiſting of a pound of ſulphure of antimony, two pounds of very pure alkali of tartar, and an ounce of ſulphur, all pulverized, is melted in a crucible. Thus melted, the mixture is poured into an iron mortar, where it is again pulverized, though not ſo completely, as ſoon as it cools: it muſt then be boiled in a ſufficient quantity of water; and this liquor filtered through grey paper, affords by cooling kermes of a brown red colour: it muſt be waſhed, firſt with cold, and after that with boiling water, till it be ſufficiently purified from any mixture of ſaline matter; it is then dried, pulverized, and paſſed through a ſilken ſieve.

To prepare *kermes* in the humid way, the ſame chemiſt directs to boil a lixivium, conſiſting of five or ſix pounds of pure fixed alkali, with fifteen or twenty pounds of river water: into this liquor, when boiling, caſt four or five ounces of levigated ſulphure of antimony; ſtir the mixture, and after it has boiled for a moment, filtre it: this filtered liquor depoſites a great deal of kermes by cooling; which muſt be waſhed in the ſame manner as that prepared by fuſion. This proceſs, according to M. Baume, affords twelve or thirteen ounces of kermes to the pound of antimony. He aſſures us, that the kermes obtained by theſe two different ways is entirely the ſame.

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The theory of this operation, or the nature of kermes, are not yet well known; tho' many eminent chemiſts have been engaged in the reſearch. It is generally thought that the alkali diſſolves the ſulphur of the ore, and that the ſulphure which is then formed diſſolves the antimony. Yet the ſemi-metal is not entirely diſſolved; for in Lemery's proceſs by the humid way, a grey powder is precipitated during the boiling of the liquor, which melts without any addition into real antimony. The precipitation of *kermes*, by the cooling of the lixivium, which though at firſt reddiſh and tranſparent, gradually looſes its colour as the *kermes* ſubſides, is another ſingular phenomenon. This compound is thought to be a kind of antimony ſuperſaturated with ſulphur, and when hot ſoluble in fixed alkali. If you make a lixivium containing precipitated kermes, the kermes will again be diſſolved by heat. The lixivium, which by cooling gave a precipitate of kermes, contains likewiſe antimoniated ſulphure of potaſh. When an acid is poured upon it, an orange matter is precipitated, known by the name of *golden ſulphur of antimony*, and much more emetic than kermes. It is thought to contain more ſulphur than kermes, and leſs of the metallic oxide.

Geoffroy, who in the years 1734 and 1735 communicated to the Academy ſeveral Memoirs concerning kermes, made a great many experiments, with a view to accompliſh an analyſis of it. He conſiders the action of acids as the moſt effectual means that can be employed for that purpoſe: theſe ſalts are thought by him to diſſolve the ſemi-metal, and leave the ſulphur naked; and thus he thinks the proportion in which the

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two principles of kermes are united in it may be eſtimated. An ounce of kermes contains, according to Geoffroy, ſeventeen grains of metal, thirteen or fourteen grains of fixed alkali, with forty, or one and forty grains of ſulphur. But many chemiſts are at preſent of opinion, that kermes contains not a particle of alkali M. Baumé ſays, that this ſalt is not one of its conſtituent principles, and may be entirely ſeparated from it, only by waſhing the maſs in plenty of boiling water. M. Deyeux, who has turned his inquiries to the ſame ſubject, agrees in opinion with M. Baumé. In a ſeries of experiments performed in conjunction with the Duke of Rochefoucauld, I have had an opportunity of being fully convinced of the ſame truth: but one fact particularly worthy of notice is, that, as the circumſtances of the preparation of kermes vary, it alſo appears to vary greatly in its nature. It may contain more or leſs ſulphur; and we may naturally infer that its effects muſt vary, according as the proportion of its principles is varied. It appears, in general, that the ſtate of the ſulphure of antimony, the various proportions in which its principles are united, and its being more or leſs attenuated or divided, as well as the quantity and the particular ſtate of the alkali in point of cauſticity, the quantity of the water, the time during which the lixivium is boiled, with many other ſuch circumſtances, produce great variations on the nature of *kermes*. In order to obtain it always with the ſame ſtrength, the proportion of the ſubſtances of which it is compoſed, and the circumſtances in which it is prepared, ſhould always be the ſame. Without entering into a very minute detail of all the phænomena

which

which kermes has offered to our obſervation, when treated with a great many different intermedia, we ſhall only add, 1. That the cauſtic alkalis produce a ſingular alteration upon it, and diſſolve it even when cold. 2. That the energy with which the acids act on this ſubſtance is much diverſified, and that it is very difficult to determine by means of them the quantity and the ſtate of the ſemi-metal, and the ſulphur which enter into its compoſition; becauſe the ſulphur ſeparated from kermes by acids carries always along with it a certain quantity of oxide of antimony.

The cauſtic alkalis act with much more energy than the effervescent alkalis on ſulphure of antimony; the former produce more kermes in proportion to their quantity; and the kermes into which they enter, is of a much deeper colour than that which owes its formation to the latter. Lime, or lime water, when digeſted over antimony in powder, affords, even without the application of heat, at the end of a few days, a kind of kermes or golden ſulphur, of a beautiful red colour. Ammoniac alters it in the ſame manner. By diſtilling ammoniacal muriate with ſulphure of antimony, we obtain a pulverulent purple ſublimate, which appears to be a kind of antimoniated ſulphure, with a baſe of ammoniac.

Laſtly, To conclude the hiſtory of the decompoſition of ſulphure of antimony, a number of other metallic ſubſtances ſeparate the ſulphur from this compound, having a greater affinity with it than antimony has. Tin, iron, copper, and ſilver, are all of them capable of effecting this decompoſition. It is only neceſſary to heat tin or ſilver with this ore till they melt. Theſe metals unite with the ſulphur, leaving the antimony in a ſolitary ſtate. Iron

and

and copper produce the ſame effect: theſe muſt be firſt filed down, and made red-hot in a crucible, after which the ſulphure of antimony is added to them, and ſoon decompoſed. The mineral haſtens their fuſion, and the ſemi-metal is ſeparated. It muſt be confeſſed, however, that the antimony obtained by theſe proceſſes is never pure: it ſtill retains a part of the metallic ſubſtances which were employed to ſeparate the ſulphur. Its form and colour always indicate this; and it is diſtinguiſhed by the name of the metal with which it is alloyed.

Antimony is employed in many of the arts; more eſpecially in caſting types for printing. It was formerly uſed as a purge. For this end, a quantity of water or wine was drunk, after ſtanding over night in veſſels of this ſemi-metal. But as the particular temperature of the place and the ſtate of the wine, as being more or leſs acid, neceſſarily rendered it uncertain what quantity of the metal might be at any time diſſolved, this medicine has been with good reaſon given up, as being very little to be truſted. For the ſame reaſon, the perpetual pills are no longer uſed, which were little balls of this ſemi-metal ſwallowed as a purgative. The ſtate of the digeſtive juices, the nature of the mucus in the primary ducts, and the differences between different individuals in point of ſenſibility, rendered the effects of thoſe pills uncertain, and frequently dangerous.

Crude ſulphure of antimony, Rotrou's ſolvent, the oxide of antimony known by the name of *diaphoretic*, kermes mineral, and golden ſulphur, are the only antimonial preparations at preſent uſed in medicine. Sul-

phure

phure of antimony is employed as a ſudorific in cutaneous diſtempers. It is ſuſpended in a linen bag in the veſſels in which ptiſans for theſe diſorders are prepared: A number of phyſicians deny that it produces any good effects when adminiſtered in this way. It is likewiſe levigated and made up into pills, which are taken for the ſame complaints.

Rotrou's ſolvent, or alkaline oxide of antimony, is recommended as a very effectual remedy in diſorders occaſioned by the thickening of the lymph; ſuch as ſcrophulous caſes, and all ſwellings of the glands in general. A number of phyſicians truſt but little to the effects of waſhen diaphoretic antimony: they think it a pure oxide of antimony, entirely deſtitute of virtue. Yet it is to be remembered, that Rouelle, the younger, found this oxide to be ſufficiently ſoluble, and that in conſequence of its poſſeſſing this property, it muſt be capable of producing ſome effects in medicine. Beſides, as we know not in what manner the gaſtric juices, and thoſe of the inteſtines, act on metallic oxides, we muſt not venture to pronounce that a ſubſtance which is apparently inſoluble and inſipid, can have no virtues when taken inwardly. Experience proves, however, that this medicine produces ſcarce any effect in the moſt obſtinate cutaneous diſorders, however long we continue to apply it. Unwaſhed diaphoretic antimony, or Rotrou's ſolvent, is preferable, becauſe, on account of its containing alkali, it is much more active than the laſt-mentioned medicine. A medicine called *La Chevclleray's powder* is ſtill uſed in ſuch caſes. It conſiſts of diaphoretic antimony calcined ſeven times ſucceſsfully, with freſh nitre each time, and lixiviated

lixiviated after each operation. It differs but very little from waſhed diaphoretic antimony; for when this ſemi-metal has been once well calcined, as it is when detonized with a quantity of nitre equal to three times its own weight, it is no longer ſuſceptible of calcination: and therefore no detonation can be obſerved in this operation. This medicine is abſolutely incapable of producing any effects when deprived of alkali.

Kermes mineral is one of the moſt valuable medicines that are prepared of antimony. It is inciſive, and is very happily adminiſtered in pituitous affections of the ſtomach, the lungs, the inteſtines, and even of the urinary paſſages. It is moſt frequently uſed in caſes when the breaſt is affected, in order to aſſiſt expectoration. It ought not to be given, however, till the inflammation be abated. It is likewiſe given ſucceſsfully, in ſmall doſes frequently repeated, in catarrhs of the breaſt, the humid aſthma, cutaneous diſorders, ſwellings of the glands, &c. It is given in doſes of from half a grain to two or three grains, in certain drinks or pills. Sometimes it occaſions vomiting; and it often occaſions ſweat, or a profuſion of urine.

Golden ſulphur, as being a violent emetic and purgative, is but little uſed. It was formerly adminiſtered in the ſame caſes in which kermes is preſcribed; but its effects are much more uncertain.

There are likewiſe ſeveral other preparations of antimony, which are very advantageouſly employed in medicine: But as they are made up with vegetable matters, we will ſpeak of them on another occaſion.

This

This is among the moſt valuable of metallic ſubſtances in medicine; and phyſicians cannot ſtudy its properties with too much attention. Scarce any other metallic ſubſtance has more engaged the attention both of alchemiſts and chemiſts; and we have deſcribed a number of valuable preparations into which it enters.

CHAP.

CHAP. XIV.

Of Zinc.

ZINC is a metallic ſubſtance, ſparkling, of a bluiſh white colour, and cryſtallized in narrow laminæ; it has neither taſte nor ſmell. It cannot be reduced into a powder like the other ſemi-metals: it yields under the hammer, and may even be beaten out a good deal, provided it have not been too much hammered before. We owe the knowledge of this property of zinc to M. Sage. When zinc is wanted to be very much attenuated, it muſt be granulated, by being poured melted into cold water, or filed down. It greaſes the files employed for this purpoſe, and fills up their teeth. Macquer ſays, that when it is expoſed to the moſt intenſe heat which it can bear without melting, it becomes ſo brittle that it may be pulveriſed in a mor-

a mortar. This property eſtabliſhes a wide diſtinction between zinc and thoſe metals which are rendered more ductile by the action of heat, and renders it eaſy for us to reduce a maſs of this metal to ſeparate particles. It may be likewiſe reduced to the ſame ſtate by triturating it when melted, and ſtirring its particles to prevent their adhering together as they cool. This operation muſt not be performed in an iron mortar, for zinc always diſſolves a portion of that metal: a marble peſtle and mortar ſhould be uſed for the purpoſe.

In water, zinc loſes about a ſeventh part of its weight. The brilliant, and in a manner regular facets, which appear in the fracture of the pigs into which zinc is made up for commerce, are a proof that this ſemi-metal is capable of cryſtallizing in a determinate manner. The Abbé Monges ſucceeded in cryſtallizing this ſemi-metal. Its cryſtals are bundles of ſmall quadrangular priſms, diſpoſed in all directions, and of a blue colour, which is changeable if expoſed to the air while the metal is hot.

M. Sage thinks zinc to be, next after iron, the moſt common of all metals. He affirms that he has found it in all martial pyrites: and M. Grignon aſſerts that the *cadmia* of the furnaces in which iron ores are treated, always contains a good deal of zinc.

Native zinc is very rare; moſt naturaliſts even doubt of its exiſtence. But M. Valmont de Bomare informs us, that he has ſeen ſpecimens of this ſubſtance in the mines of lapis calaminaris in the Dutchy of Limburgh, and in the mines of Goſſard. It was in ſmall pliant filaments, of a greyiſh colour, and very inflammable.

This metal is oftenest found in the ſtate of oxide; it then conſtitutes the *lapis calaminaris*, which in point of form is ſubject to very many varieties. Sometimes it is in cubic, priſmatic, foliated, or laminated cryſtals; but oftenest in irregular maſſes. Its colour too varies. It is ſometimes white, ſometimes grey or yellow, and ſometimes reddiſh. It is a hard body, but never ſo very hard as to give fire with ſteel. It is found in pretty large quarries in the Dutchy of Limburgh, in the county of Namur, and in Nottingham and Somerſetſhires in England. Theſe quarries of *lapis calaminaris*, are often found to contain marine bodies, calcareous ſpar, &c.; a circumſtance which proves them to have been depoſited by water. The lapis calaminaris is ſtill called *natural* or *foſſil cadmia*. Bergman, who has analized zinc ores in a very accurate manner, has found almoſt all calamines to contain ſiliceous and aluminous earth, and oxide of iron in various proportions: calamines contain from .04 to .30 of metal.

The Abbe Hany has diſcovered that all cryſtallized calamines have the electric powers of the tourmaline. The zeolitiform calamine has been analized by M. Pelletier, and the reſults publiſhed in the *Journal de Phyſique*. It is in ſmall laminæ, not at all like the zeolite. They form a jelly with acids; and naturaliſts have therefore done wrong, to confound them with the zeolite.

Zinc, in combination with ſulphur, forms what is called *blende* or *falſe galena*. This ſulphure of zinc is commonly in ſcales; ſometimes it appears in cubic cryſtals, more or leſs truncated. As to colour, it is ſometimes lead coloured, but generally black or reddiſh: There is alſo found at Ronſberg in Norway, at Goſlard, and at St Marie, a yellow and tranſparent ſpecies of this

ſubſtance.

ſubſtance. Some blendes are phoſphoric when rubbed in the dark. Some of them poſſeſs this property in ſuch a degree, that all that is neceſſary to make them diſplay it, is to rub them with a tooth-pick. Blende has received the name of *ferile nigrum*; becauſe, when melted, in order that the zinc which it appears to contain might be extracted, no zinc is obtained, as the ſemi-metal is volatilized while it is in fuſion. All blendes, when they are either rubbed or diſſolved in acids, exhale a very ſenſible ſmell of liver of ſulphur. Cronſtedt thinks them to conſiſt of zinc combined with ſulphur by the intermedium of iron. M. Sage is of opinion, that they contain an earthy ſulphure, or liver of ſulphur.

Zinc is likewiſe found in a ſaline ſtate, combined with the carbonic, or with the ſulphuric acid. The firſt of theſe compounds is known by the name of *nitreous zinc ore*, or *flower of zinc*. This ore is white, grey, or bluiſh, and gives fire with ſteel: it is ponderous, ſometimes cryſtallized, and ſometimes ſtalactitical, or irregularly ſhaped. It diſſolves with effervescence in acids, giving out carbonic acid. Bergman reckons every 160 grains of it to contain 65 of oxide of zinc, 28 of carbonic acid, 6 of water, and 1 of iron.

Native ſulphate, or vitriol of zinc, is found in rhomboidal cryſtals or white ſtalactites. It is often cryſtallized, like amianthus, in ſilky filaments, or in fine needles: it is ſometimes confounded when in this ſtate with *feather-alum*. It is found in Italy, and in the mines of Goſlard in Hartz.

We may now proceed to arrange zinc ores in the following manner, according to the ſeveral ſtates in which the ſemi metal is found.

State I. Native zinc.

1. In pliant filaments, greyiſh, and inflammable.

State II. Zinc in Oxide; *Calamine.*

Varieties.

1. Oxide of zinc, or white calamine in tetrahædral priſmatic cryſtals, ſhort and bundled together in a confuſed manner. It ſometimes inclines to green.
2. Oxide of zinc, or calamine cryſtallized in pyramids, reſembling the hog's tooth calcareous ſpar: its colour, white, grey, greeniſh, or reddiſh. Meſſrs Sage and Romé de Lille think that this calamine is produced by the decompoſition of calcareous ſpar. It is indeed often found to be in part calcareous and hollow within.
3. Solid, and as it were worm-eaten oxide of zinc or calamine. It is furrowed, cellular, and in ſome manner cryſtallized in dendrites.
4. Solid, compact calamine or oxide of zinc; *lapis calaminaris.* That which we get from the county of Namur is always calcined. There is an order againſt exporting it till it have undergone that operation.
5. Oxide of zinc, or calamine in greeniſh or yellowiſh ſtalagmites.
6. Oxide of zinc, or calamine in a zeolite form, known by the name of *Zeolite of Friburgh.* M. Pelletier has diſcovered that this pretended pearl-coloured zeolite contains to 100 parts,

Varieties.

parts,—from 48 to 52 of siliceous earth, 36 of oxide of zinc, and from 8 to 12 of water.

State III. Zinc mineralized by sulphur: Sulphure of zinc, blende.

The principal varieties of this ore are to be distinguished by their diversities of form. Cubic blende has been so called by mistake. The following are the varieties of its forms mentioned by M. Hauy.

Varieties.

1. Duodecahædral blende with rhombic facets. This is the primitive form, and is obtained by the subdivision of the crystals. It has not yet been found in nature without additional facets.
2. Blende with 12 trapezoids and 12 triangles.
3. Blende in regular octohedrons.
4. Blende in regular tetrahedrons.
5. Beside these five varieties regarded by mineralogists as species, there are others distinguished by colour; the grey, with a metallic aspect, the black, the red, or reddish brown, the yellowish green, the waxen yellow, &c. These are all either shapeless or crystallized.
6. Blendes may be discriminated by their more or less sensible phosphorescence upon friction, and by the fœtid odour of sulphurated hydrogene, which they emit, when rubbed or heated.
7. Sulphure of zinc or decomposed blendes, the lamine of which are detached, and their lustre destroyed. This becomes an oxide of zinc or calamine.

State IV.

Varieties.

1. Carbonate of zinc, ſparry zinc, or vitreous ore of zinc.
2. Sulphate of zinc, in rhomboidal cryſtals, in ſtalactites, or in ſilky filaments.

In aſſaying calamine, it is generally ſufficient to reduce it to powder, to mix it with coal, and to heat the mixture in a crucible covered with a red copper plate; on which the copper immediately becomes yellow, and is converted into braſs. Bergman has analized calamine much more accurately by the humid way: he made uſe of the ſulphuric acid in analizing pure calamine and carbonate of zinc: the ſolution he found to contain both ſulphate of zinc and ſulphate of iron; the laſt he decompoſed by a known weight of zinc, and afterwards precipitated it with carbonate of ſoda. He has determined, that 193 grains of this precipitate are equal to 100 grains of zinc; from the weight of the precipitate he deducts the weight of the zinc employed to precipitate the iron.

As moſt calamines are of a more compound nature than this, and contain ſiliceous earth, aluminous earth, and chalk combined with oxide of zinc, of iron, and oxide of lead; Bergman firſt treats thoſe ores three times ſucceſſively with two parts of nitrous acid each time: on heating them till they become dry, the acid calcines the iron, and renders it inſoluble; the ſecond addition of nitric

nitric acid ſerves to diſſolve whatever is ſoluble; and the iron, the ſiliceous earth, and the aluminous earth, remain ſeparate. The acid holds in ſolution the calcareous earth and the oxides of zinc and lead. The muriatic acid is employed to precipitate the oxide of lead; the ſulphuric acid to ſeparate the lime; as to the lime it is precipitated by the alkaline pruſſiates. Bergman takes one fifth of the weight of this precipitate to be the oxide of the zinc contained in the calamine. He has employed likewiſe another proceſs, in which he diſtilled the ſulphuric over calamine till only a dry reſidue remained; this reſidue he lixiviated in hot water: he then precipitates this lixivium with cauſtic ammoniac, which ſeparates the iron and the aluminous earth, but not the oxide of zinc, which is ſoluble in ammoniacal ſulphate.

As to the aſſaying of blendes, formerly they were firſt roaſted, and then treated in the ſame way as calamines. M. Monnet firſt aſſerted that theſe ores might be very well aſſayed by diſſolving them in aquafortis, which combines with the metallic ſubſtance, and ſeparates the ſulphur. The oxide of zinc is then reduced, after being ſeparated by diſtillation from the nitric acid. Bergman has made a ſeries of experiments on theſe ores, no leſs accurate than thoſe which he has made on calamines; and has purſued M. Monnet's concerning the aſſaying of them by the humid way to a much greater length. He firſt ſeparates by diſtillation, the water, the arſenic, and a part of the ſulphur which they contain: he next treats them with ſuch acids as act upon them with the moſt force; and finiſhes the operation by precipitating theſe ſolutions with various re-agents.

The ores of zinc are not wrought in order to extract the semi-metal which they contain. By melting lead-ore mixed with blendes, zinc is obtained in the form of oxide; which is sublimed in the chimnies of furnaces, and there produces greyish incrustations, which are called *tuttia* or *cadmia fornacum*. Another portion is obtained in the metallic form by cooling the anterior part of the furnace. The zinc being reduced to vapour by the action of the fire, is there condensed, and falls in grains on powder of charcoal, covering a stone placed beneath in the furnace. The powder of coal preserves the semi-metal from being calcined; it is then melted anew in a crucible, and cast into pigs. This is the process by which the greatest part of the zinc which passes in commerce is obtained at Rammelsberg, either in oxide or in metal. This zinc is always combined with a portion of lead which alters its nature. That which is prepared in China, and comes to us from the Indies, under the name of *tutenag*, is much purer *; but we are unacquainted with the process by which it is prepared. M. Sage says, that the English extract zinc, in the great way, from lapis calaminaris by distillation; but the apparatus which they employ is kept a secret.

Zinc exposed to heat in close vessels melts on becoming red-hot, and volatilizes without being decomposed. If suffered to cool slowly in a vessel from which a part of the melted semi-metal may run out, the remaining part crystallizes into needled prisms. M. Monge uses for

* Kirwan gives the name of *tutenag* to a variety of the brittle calamine of China, of which M. Engerstrom has given an analysis in the Memoirs of Stockholm, 1775. That ore is very rich, and contains from $\frac{4}{5}$ to $\frac{9}{10}$ of zinc.

for this purpoſe a roaſting pot with ſeveral holes in its ſides and bottom, which he ſtops with earth of bones. When the ſurface of the zinc cools, all the holes are gradually ſtopped; and the metal is ſtirred with a red iron introduced by one of them. This ſimple proceſs cauſes the melted zinc to run out; and the roaſting pot is then ſhaken till the metal ceaſe to run, and the portion which is cool cryſtallize. If left in the veſſel, it takes a metallic colour: if expoſed to the air, it aſſumes the ſhades of the rainbow. When melted zinc is brought into contact with the air, it is covered with a grey pellicle, which is ſoon converted into a yellowiſh oxide, not very refractory, but eaſily reducible. This oxide weighs more than the zinc of which it is formed; but if the ſemi-metal be violently heated, it burns with a white or a greeniſh yellow flame, which is very brilliant, and reſembles the flame of phoſphorus. The oxide is carried up and volatilized by the current of this flame, but condenſes in the air into the form of very little white flakes, which are called *flowers of zinc*, *pompholix*, *nihil album*, *philoſophical wool* or *cotton*. They are a thoroughly calcined oxide of zinc; and their gravity is greater than that of the ſemi-metal from which they are formed: for M. Baumé obtained ſixteen ounces ſix drachms and fifty four grains of this oxide from a pound of zinc. It is not volatile of itſelf; and its ſublimation is owing to the rapidity with which the zinc burns; for if this oxide be expoſed to fire after being volatilized, it remains fixed: it retains a phoſphoric light which it diſplays in the dark; it melts into a glaſs; but a very intenſe heat is requiſite: Vitrified oxide of zinc is of a beautiful pure yellow colour.

The

The oxide and the glaſs of zinc are nothing but a combination of the ſemi-metal with oxigene, or the baſe of vital air. The only difference between the white oxide and the glaſs ſeems to be, that in the latter the principles are more intimately united. This compound is one of thoſe metallic oxides which are indeſtructible; nor can it be reduced without the addition of another body. In order to reduce it, we muſt bring it into contact with ſome combuſtible ſubſtance. On expoſing to an intenſe heat a mixture of white oxide of zinc with coal or any other combuſtible matter, zinc is obtained; and the coal is partly burnt by means of the oxigene, of which it robs the metallic oxide. Zinc has therefore leſs affinity than coal with oxigene, though it appears to be the more combuſtible of the two. This operation ſucceeds beſt in cloſe veſſels: and we are told, that the Engliſh reduce lapis calaminaris by diſtillation.

Zinc is ſcarce alterable by air: only its ſurface is a little tarniſhed, and it ſeems beginning to oxidate.

Water acts powerfully on zinc when the ſemi-metal begins to become red-hot. It eaſily reduces zinc to an oxide, giving out at the time a good deal of hydrogenous gas, which ſhows that it is decompoſed by the ſemi-metal, which with the help of an high temperature deprives it of its oxigene. Meſſrs Lavoiſier and Meuſnier were fully convinced of this fact by their experiments on the decompoſition of water. A little carbonaceous matter from the zinc is held in ſolution by the hydrogenous gas obtained in this proceſs.

Zinc has no power of action on ſiliceous or on alumi-nous earth; but its oxide enters into vitreous com-pounds, and communicates a yellow colour to glaſs.

Neither barytes, nor magneſia, nor lime, acts upon zinc.

When liquor of cauſtic potaſh or ſoda is boiled over this ſemi-metal, it blackens its ſurface, and diſſolves a certain quantity of oxide, which, as M. de Laſſonne has ſhown, may be ſeparated from it by acids. Ammoniac acts leſs effectually on zinc hot, on account, no doubt, of its volatility: when it is digeſted cold, however, over zinc, it diſſolves a little of it. In the ſolution of zinc by the three alkalis, a certain quantity of hydrogenous gas is diſengaged; the production of which is owing to the decompoſition of the water: ſo that it is this fluid which acts on the ſemi-metal, reduces it to an oxide, and renders it in part ſoluble in alkalis.

The ſulphuric acid, diluted in water, diſſolves zinc cold. As the ſolution takes place, the ſemi-metal aſ-ſumes a blackiſh grey; a conſiderable degree of heat is excited; and a black powder is precipitated; the na-ture of which was long unknown, but which is now known to be *plumbago*: a good deal of hydrogenous gas, with a little carbonaceous matter diſſolved in it, is diſenga-ged. This elaſtic fluid, which has the ſame ſmell as the gas obtained when iron is diſſolved by the ſame acid, is cer-tainly owing to the water; for the concentrated ſulphu-ric acid never diſſolves zinc without the help of heat, and the gas which it then affords is ſulphureous. The water, therefore, begins with oxidating the zinc, and the acid then diſſolves the oxide of the ſemi-metal. When hydrogenous gas is no longer diſengaged, the ef-

ferveſcence ceaſes, and the ſmell of the ſolution changes, becoming perfectly the ſame with that of greaſe a little rancid. The liquor is whitiſh and ſomewhat turbid: by dilution in water it becomes tranſparent. When evaporated it affords a white ſulphate of zinc, rather more ſoluble in hot than in cold water; of which a portion cryſtallizes by cooling. This ſalt may be eaſily enough obtained in very regular cryſtals, which are uſed in the arts under the name of *white copperas*, *white vitriol*, *Goſlard's vitriol*. On expoſing to the air for a few days a ſolution of this ſalt in boiling water, a little evaporated, it affords tetrahedral priſms, terminating in pyramids having likewiſe four ſides: the ſides of theſe priſms are ſmooth. Such is the form which Meſſrs Sage and Romé de Lille aſcribe to them, and my obſervations enable me to confirm what they have advanced. Bucquet obſerved the priſms to be rhomboidal; yet M. Monnet aſſerts, that it is very difficult to make this ſalt cryſtallize, and that it is obtained in regular cryſtals without efflorescency, by being violently evaporated and ſuddenly cooled. The white oxide of zinc likewiſe diſſolves in the ſulphuric acid, forming the neutral ſalt of which we are ſpeaking.

This ſalt has a pretty ſtrong ſtyptic taſte. According to Hellot, it loſes a part of its acid by the action of fire. That acid poſſeſſes the characteriſtic properties of the ſulphureous acid: it becomes hot when mixed with the concentrated ſulphuric acid, as has been remarked by Macquer. After being expoſed to the action of fire, this ſulphate of zinc appears to be converted into ſulphite of zinc; the properties of which are not well known. Sulphate of zinc, when very pure, ſuffers ſcarce

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any alteration from air: in time its oxide becomes more completely calcined by abſorbing more oxigene: it then becomes yellow, and not entirely ſoluble in water. Sulphate of zinc is decompoſed by aluminous earth, barytes, magneſia, lime and the three alkalis. The oxide of zinc precipitated by theſe ſubſtances may be again diſſolved in acids, and even in alkalis. Ammoniac acquires, in this ſolution, a dirty brown colour. Sulphate of zinc decompoſes nitre, and is itſelf decompoſed by that neutral ſalt. By diſtilling this mixture, two kinds of nitrous acid are obtained, which do not mingle together, as well as glacial ſulphuric acid. We will ſpeak more particularly on this matter under the article ſulphate of iron, or *martial vitriol*.

We find in commerce a ſulphate of zinc under the name of *white copperas*, which is prepared in the great way at Goſlard. Blende is roaſted; a portion of the ſulphur then burns, and affords ſulphuric acid, which diſſolves the oxide of zinc. The ore is next waſhed; and the lixivium, after being ſuffered to ſettle, is decanted off, evaporated, and thus cryſtallized. This ſalt is then melted by a moderate heat, in order to free it from the water of its cryſtals, and left to cool. By this proceſs it is condenſed into white, opaque, and grained maſſes like ſugar. *Vitriol of Goſlard*, when diſſolved in boiling water, cryſtallizes by cooling; and its cryſtals are a little reddiſh. The colour is aſcribed to the impurities of the ſalt: which is thought to contain a ſmall portion both of lead and of iron. To purify it, a little zinc may be caſt into the ſolution. This ſemi-metal precipitates the oxide of lead and iron, becauſe it has a greater affinity with the ſulphuric acid than

than they have. The liquor is now filtrated; and after paſſing through the filter, contains nothing but pure ſulphate of zinc. What eſpecially leads us to think it oxide of iron which often alters the *vitriol of Goſlar* is, that the zinc which paſſes in commerce is ſometimes attracted by the loadſtone; a property which it muſt no doubt, owe to iron. If a perſon were to make experiments, therefore, on this ſemi-metal, it would be proper to uſe no ſpecimens but ſuch as he had himſelf prepared by reducing precipitate of ſulphate of zinc, after purifying it as we have directed. We muſt, however, obſerve, that the reaſon why pigs of zinc are attracted by the loadſtone at the part where they have been cut, is often nothing but their having been cut with iron ſciſſars or wedges.

The nitric acid, when weak and diluted in water, combines with zinc cold, and with great rapidity. A conſiderable heat is produced on this occaſion, as well as when the ſame ſemi-metal is diſſolved in the ſulphuric acid. The lively effervoſcence which takes place when this combination is effected, occaſions the diſengagement of a great quantity of nitrous gas, which the air renders inſtantly red when the operation is performed in an open veſſel: but by itſelf this gas is colourleſs; and it may be collected under water by immerſing into a quantity of that fluid the extremity of the veſſel containing the mixture. This experiment proves that zinc decompoſes the nitric acid by robbing it of a part of its oxigene. If the zinc be mixed with a little iron, it is covered with a reddiſh ochreous powder; which is nothing but a portion of that metal thoroughly calcined by the acid: if pure, it precipitates ſome flakes of a black

a black matter, or carbure of iron, in the ſame manner as when in combination with the ſulphuric acid: a much greater proportion of oxide of zinc will remain diſſolved in the nitric than in the ſulphuric acid. M. Baumé ſays, ſix ounces of this acid diſſolve five drachms and an half of zinc in leſs than two hours. The nitric ſolution of zinc is of a greeniſh yellow colour, and a little turbid when new made; but after being ſuffered to ſettle for ſome time, it loſes this colour and becomes tranſparent. Altho' the acid with which it is made be diluted in water; yet it is ſo very cauſtic as to corrode the ſkin. I obtained from this ſolution by evaporation and cooling, cryſtals in compreſſed and ſtriated tetrahedral priſms, terminating in four-ſided ſtriated pyramids. When this nitrate of zinc is placed on burning coals, it immediately melts and runs into ſeparate portions, which detonate as they become dry; and the detonation is attended with a faint reddiſh flame. It does not, however, exhibit the ſame phænomenon when melted in a crucible: it cannot then be dried even by the moſt moderate heat without ſuffering ſome alteration. Nitrous gas eſcapes from it; its colour becomes a brown red, and its conſiſtency gelatinous. If cooled when in this ſtate, it retains its ſoftneſs for ſome time; and if the application of heat be continued, it dries ſuddenly up into a yelloviſh oxide. Hellot obtained from nitrate of zinc by diſtillation a very fuming nitrous acid; and obſerved it to aſſume a red colour in melting. It may be underſtood, that when heat diſengages nitrous gas from this ſalt, it paſſes into the ſtate of *nitrite of zinc*: It affords alſo a certain quantity of oxigenous gas or vital air. Nitrate of zinc readily

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attracts the moiſture of the atmoſphere; on which event it loſes its regularity of form. What remains of the cryſtals of this ſalt, after a few days expoſure to the air, is only ſtriated pointed priſms without any determinate form. We know not whether it be decompoſable by other acids. Meſſrs Pott and Monnet affirm, that oxide of zinc has a ſtrong affinity with all theſe ſalts; but does not combine with any one of them in preference to the reſt. According to Hellot, oxide of zinc forms the ſame ſalt by ſolution in the nitric acid. If nitrous acid be employed to effect this ſolution, nitrite of zinc is produced; the nature of which is not exactly known.

The muriatic acid acts on zinc in as rapid a manner as the nitric acid. A conſiderable quantity of hydrogenous gas is diſengaged during the lively effervescence with which this act of combination is accompanied: its properties are the ſame with thoſe of the hydrogenous gas produced by the ſulphuric acid acting upon this ſemi-metal; and, as in that inſtance, it ariſes from the water decompoſed by the zinc. A blackiſh matter is gradually depoſited in flakes by the liquor; which can be nothing but a combination of carbonaceous matter with iron. The ſolution of zinc by the muriatic acid is colourleſs; nor does it afford cryſtals by evaporation. When heated, it aſſumes a blackiſh brown colour, exhales the acrid and pungent vapours of the muriatic acid, and becomes much thicker: it has been expoſed to the air in this ſtate for eight days without giving cryſtals. By diſtillation it affords a ſmall portion of very fuming muriatic acid and ſolid fuſible muriate of zinc. Meſſrs Hellot and Monnet have given very good

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deſcriptions of this operation. In my courſes of lectures I have repeated it ſeveral times, and have obtained, firſt, a ſmall portion of yellowiſh acid, and afterwards a congealed matter in the neck of the retort. This muriate of zinc was of a beautiful milk-white colour, very ſolid, and formed, like ſtalactites, of ſmall radiated needles: it melts by a mild heat. I preſerved ſome of it for a number of years in well-ſtopped glaſs-flaſks; it had acquired but little moiſture in all that time; the parts which touched the glaſs were become a little yellowiſh, and the bottom of the glaſs was coloured like a rainbow. This alteration is no doubt the effect of light. In the retort uſed in the above proceſs of diſtillation there remains a vitriform and deliqueſcent blackiſh matter. The muriate of zinc which Hellot obtained by diſtillation was yellowiſh; the ſulphuric acid, he ſays, diſengages the muriatic acid. We know nothing of oxiginated muriate of zinc.

The liquid carbonic acid, when zinc or oxide of zinc is put to digeſt in it, diſſolves, according to Bergman, a pretty conſiderable quantity of it in the ſpace of twenty four hours. This ſolution, when expoſed to the air, is covered over with a pellicle which reflects various colours, and is actually, according to the celebrated chemiſt above quoted, carbonate of zinc.

We are not as yet well acquainted with the manner in which the fluoric and the boracic acids act upon zinc.

All ſolutions of zinc in acids are precipitated by lime-water, magneſia, fixed alkali, and ammoniac. The oxide of this metal then appears in the form of white or yellowiſh flakes, according to the ſtate of the ſolution

and the purity of the precipitant. It may be reduced by means of zinc: it is ſoluble in acids and alkalis. By adding more alkali than is requiſite to precipitate the oxide of zinc diſſolved in an acid, the precipitate is cauſed to diſappear gradually, and the liquor to aſſume a dirty yellow colour; an indication that the oxide is diſſolved in the alkali. When, inſtead of pure or cauſtic alkalis, carbonate of potaſh, ſoda, or ammoniac is employed to ſeparate zinc from acids, there is ſcarce any effervescence; the precipitate is whiter than in the former caſe, and the carbonic acid appears to unite with the oxide of zinc; ſo that in this caſe there are two decompoſitions and two new combinations.

Zinc decompoſes a number of the neutral ſalts: When expoſed to fire in a crucible with ſulphate of potaſh, it decompoſes that ſalt, and forms ſulphure of potaſh, in the ſame manner as antimony. In this proceſs, the zinc ſeizes the oxigene of the ſulphuric acid; and the acid paſſing into the ſtate of ſulphur, is then diſſolved by the potaſh: the ſulphure formed by this combination diſſolves a portion of the oxide of zinc. All ſulphates are equally liable to be decompoſed by zinc.

When this metal is reduced to filings or powder, it makes nitre detonize with amazing rapidity. If the mixture be made very dry, and caſt by ſpoonfuls into a red crucible, it produces a clear red flame. So vigorous is this inflammation, that it darts the burning matter to a diſtance from the crucible; which renders it neceſſary for the operator to be very cautious. The zinc burns with the help of the oxigene of the nitre which is decompoſed, and is reduced to an oxide, which

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is more or leſs complete according as a greater or a leſs quantity of nitre has been employed. A part of the reſidue is ſoluble in water. That part conſiſts of potaſh in combination with ſo much of the oxide of zinc, and may be precipitated by acids. Reſpour aſcribed to this ſolution the property of diſſolving all metals; if we may believe Hellot, who has given it as the *alkaheſt* of that alchemiſt.

Zinc appears from Pott's experiments to be capable of decompoſing muriate of ſoda. It acts with peculiar force in decompoſing ammoniacal muriate: M. Monnet affirms, that when this ſalt is triturated with the ſemi-metal, there is ammoniac diſengaged. Bucquet has obſerved, that when this ſalt is diſtilled with zinc, a good deal of ammoniac gas is obtained, as well as of hydrogenous gas, produced when the muriatic acid enters into combination with the ſemi-metal. The diſengagement of the ammoniac, ſo eaſily effected, he perceived to be owing to the lively re-action of the zinc on the muriatic acid. Oxide of zinc is alſo diſengaged on the occaſion, according to Hellot. The reſidue of this decompoſition is muriate of zinc, which may be ſublimated.

When a ſolution of aluminous ſulphate is boiled with filings of zinc, it is decompoſed, and ſulphate of zinc is formed in conſequence of its decompoſition. The baſe of that ſalt therefore appears to have leſs affinity than zinc with the ſulphuric acid. We owe this fact to Pott. We will hereafter have occaſion to make a ſimilar obſervation concerning ſeveral other metallic ſubſtances.

The effects of hydrogenous gas on zinc have not yet been attended to; only I have obſerved, that if the ſemi-metal be immerſed into the gas, it aſſumes after ſome time a very bright changeable blue colour; but I have not purſued this alteration farther. It does not reduce the oxide of this ſemi-metal, which retains its oxigene with ſo much force as even to decompoſe water.

Zinc appears at firſt to be almoſt incapable of combining with ſulphur. When theſe two ſubſtances are melted together, they melt without entering into any kind of union. Yet M. Dehne has obſerved, that if they be kept together in fuſion for ſome time, the zinc is partly calcined, aſſumes a brown or a grey colour, and acquires an increaſe of weight. M. de Morveau has ſince diſcovered, that oxide of zinc combines eaſily with ſulphur by fuſion, producing by this combination a grey mineral, very like the *blende* of Huelgoet. Sometimes bright yellow priſmatic needles are found ſticking to the lid of the crucible in which this combination is accompliſhed. M. de Morveau obſerves, that it is the more probable that the natural *blende* is formed by the combination of oxide of zinc with ſulphur, as we find no native zinc.

M. Malouin did not ſucceed in combining zinc with alkaline ſulphure, though he attempted it both in the humid and the dry way, and with various proportions of the ſubſtances.

The ſame chemiſt combined zinc with arſenic. He has obſerved that it does not unite ſo well with the oxide of arſenic. However, in an experiment in which he diſtilled a mixture of oxide of arſenic, tallow, and zinc,

zinc, he obtained a blackiſh maſs reſembling blende, but ſofter than that ore. It appears likewiſe, that when zinc and oxide of arſenic are diſtilled together, the former deprives the latter of a part of its oxigene; for part of the ſemi-metal is calcined, while part of the oxide paſſes into the metallic ſtate. It would be of conſiderable ſervice to chemiſtry to determine, by a ſeries of experiments, the reciprocal action of metals and metallic oxides; together with the various degrees of affinity with which oxigene adheres to each of theſe ſubſtances.

We know not whether it be poſſible to combine zinc with cobalt.

It does not combine with biſmuth; and when theſe two ſemi-metals are melted together, the biſmuth, being the moſt ponderous of the two, ſinks under the zinc, and they may be ſeparated by a blow with an hammer.

When zinc is melted with antimony, it gives an hard brittle mixture, which Malouin only mentions.

Zinc is of great uſe in the arts. It enters into ſeveral metallic mixtures; particularly in tombac and prince's metal. Filings of zinc are mixed with powder, to produce bright ſparkling artificial ſtars in fire-works. Several perſons have propoſed the uſe of this metal as being ſtill more effectual than tin for plating over the inner parts of copper veſſels. Malouin, after comparing theſe two metallic ſubſtances, in two Memoirs, which appear among thoſe of the Royal Academy of Sciences for the years 1743 and 1744, gives an account of ſome experiments which he made concerning the plating of copper veſſels with zinc. The reſult of his reſearches

is, that this kind of plating might be more exactly ſpread over the copper, and would be much harder and much leſs liable to melt than a plating of tin; and of conſequence more laſting, and leſs likely to fall off the copper. Macquer acknowledges theſe advantages, but makes ſome very important obſervations on the uſe of zinc for plating kitchen utenſils. He thinks it dangerous, becauſe it is ſoluble in vegetable acids, ſuch as vinegar, verjuice, &c. and is a pretty ſtrong emetic. He proves this laſt fact by vitriol of zinc, which was formerly adminiſtered to excite vomiting, under the name of *gilla vitrioli*, and referring to Gaubius, who mentions a celebrated remedy for convulſive complaints, known by the name of *luna fixata Ludemanni*, as being ſublimated oxide of zinc. This luna fixata was a ſtrong emetic, and was adminiſtered in very ſmall doſes. But may we not preſume that theſe obſervations can refer only to ſulphate of zinc, and to the oxide of that ſemi-metal, and reſpect neither the ſemi-metal itſelf, nor the ſalts which it forms by combining with vegetables? M. de la Planche, doctor in medicine of the faculty of Paris, has, by a ſet of experiments made with care upon himſelf, determined theſe conjectures to be not only plauſible, but certainly true. He ſwallowed ſalts formed by zinc with vegetable acids, in much ſtronger doſes than what could poſſibly be contained in any aliments prepared in copper veſſels plated with tin, without ſuffering from them any bad effects. However, as too much attention cannot be paid to whatever concerns the health and lives of mankind in general, it would certainly be highly improper to form any decided opinion concerning this matter, till it be determined

determined by a great many experiments in what manner zinc and the ſalts which it forms with vegetable acids can affect the animal œconomy.

The German phyſicians employ ſublimated oxide of zinc ſucceſsfully as an antiſpaſmodic in convulſions and epileptic fits. It is not much uſed in France. It might, however, be of ſome utility if given in pills, and in doſes of half a grain a-day. I am told, that at Edinburgh a much more conſiderable doſe has been given without any ſenſible effects. This fact contradicts what Gaubius tells of the emetic powers of zinc.

Pompholix, *tuttia*, &c. are uſed as excellent deiccatives for humours affecting the eyes, &c.

CHAP. XV.

Of Mercury.

MERCURY, or quickſilver, has the opacity and brilliancy of metals; next after gold and platina, it is the moſt ponderous ſubſtance known. A cubic foot of mercury, if very pure, weighs nine hundred and forty-ſeven pounds; in water it loſes one-thirteenth of its weight. As it is habitually fluid, we know nothing concerning its ductility or tenacity, and are at a loſs what rank to aſſign it among metals. However, its exceſſive weight, habitual fluidity, extreme volatility, together with the ſingular alterations which it is liable to ſuffer by combination, cauſe it to be conſidered with great probability as a peculiar ſubſtance, not otherwiſe related to metallic matters, but by its brilliancy, gravity, and combuſtibili-

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ty; which might therefore be with more propriety claſſed by itſelf.

It was long thought that mercury could not loſe its fluidity; but the academicians of Peterſburgh have proved the contrary. Thoſe philoſophers made a number of experiments upon it during the ſevere cold of the year 1759, by a mixture of ſnow with fuming ſpirit of nitre, till the mercury fell in a thermometer graduated after de Liſle to 213 degrees, correſponding to 46 degrees below the freezing point in Reamur's thermometer. Thoſe gentlemen, obſerving that the mercury then ceaſed to ſink, broke the glaſs in which it was contained, and found it frozen into a ſolid body, which might be beaten out by the hammer. From this experiment it appears that mercury is ſuſceptible of concretion like other metallic ſubſtances; and in that ſtate poſſeſſes a certain degree of ductility. They could not exactly eſtimate the ductility of mercury; for at every ſtroke of the hammer, ſome point of the metal became ſo hot as to melt and run.

M. Pallas, in the year 1772, ſucceeded in effecting the congellation of mercury at Kraſnejark, by a natural cold of $55\frac{1}{2}$ degrees; and obſerved, that it then reſembled ſoft tin; that it might be beaten out into thin plates; that it might be eaſily broken, and the fragments, when placed near each other, united of themſelves. Mr Hutchins, in 1775, obſerved the ſame facts at Fort Albany; and Mr Bieker at Rotterdam in 1776, at 56 degrees below Zero. At laſt, in the year 1783, the congelation of mercury was effected in England by a more moderate heat; and 32 degrees

grees under Zero, in Reaumer's thermometer, was determined to be the term at which this congelation takes place. The mercury's falling lower in former inſtances, is therefore to be aſcribed to the contraction or condenſation of the ſolid metal. Mercury is therefore the moſt fuſible meral known; the moſt intenſe cold that is known in thoſe countries in which it is native is never ſufficient to render it ſolid. Probably, if in the above experiments the cold which froze mercury had been gradually applied to it, it would have cauſed that metallic matter to aſſume a regular cryſtalline form.

The habitual fluidity of mercury has cauſed it to be conſidered as a peculiar metallic water, and it has been called *aqua non madefaciens manus*; water that does not wet the hands. It is true, mercury does not wet the hands, nor any of thoſe bodies which are liable to be made wet by water, oil, and other liquors: but the cauſe of this phænomenon is, that there ſubſiſts but little affinity between this metallic fluid and thoſe bodies. For, when mercury is brought into contact with any ſubſtance with which it can combine, ſuch as gold, ſilver, tin, &c. it adheres to theſe bodies, and wets them to ſuch a degree, that they cannot be dried without evaporating over a fire the mercury with which they are coated.

Mercury being a metal in fuſion, when divided into ſmall parts always takes a perfect globular form; when incloſed in a phial, its ſurface is convex. This laſt phænomenon depends on mercury's having ſo little affinity with glaſs, and on the ſtrong mutual attraction of the integrant parts of this metal; for when mercury is put into

into a metal veſſel with which it has an affinity, its ſurface appears concave, like that of any other fluid, as it then combines with the ſides of the veſſel.

The taſte of mercury is imperceptible to the nerves of the organs of taſte; but it produces a pretty ſtrong effect on the ſtomach and the inteſtines, as well as on the ſurface of the ſkin. Inſects and worms are much more ſenſible of its taſte than any other animal. Mercury kills them very quickly, and is therefore preſcribed by phyſicians as an excellent cure for worms. Some ſkilful phyſicians have been induced to think, from its poſſeſſing the power of curing the itch and ſeveral cutaneous diſorders, that theſe are occaſioned by certain inſects penetrating thro' the texture of that organ. But this opinion has not been generally adopted, though ſeveral naturaliſts have deſcribed the animal which cauſes the itch, &c.

Mercury, when rubbed between the fingers, exhales a peculiar faint ſmell. If it be ſhaken when very pure, it is ſometimes, and particularly in hot weather, obſerved to ſparkle with a phoſphoric light, which, tho' not ſtrong, is yet ſufficiently diſcernible. Many natural philoſophers have obſerved this of the mercury of the barometer. On immerſing the hand into this metallic fluid, a perſon feels a ſenſation of cold, which would ſuggeſt that its temperature is colder than that of the atmoſphere: but on immerſing a thermometer, we ſoon find the temperature of the maſs of mercury to be the ſame with that of the atmoſphere. This phænomenon, which eludes our obſervation, muſt be entirely owing to the mercury's attracting the heat from the hand with great

rapidity;

rapidity; for mercury is known to be a powerful conductor of heat.

When mercury is divided by a rapid and continued motion, ſuch as that of a mill-wheel, is is by degrees converted into a very fine black powder, called *Æthiops per ſe*, on account of its colour: as mercury is in this inſtance in ſome degree calcined, we call this powder *black oxide of mercury.** On being expoſed to a moderate heat, or triturated in an hot mortar, it recover its uſual fluidity and metallic luſtre.

Mercury is not one of thoſe metals which are moſt plentiful in nature. It is found in the earth, either in a virgin ſtate, poſſeſſing all its properties, or in a ſtate of oxide, or in a combination with acids, ſulphur, and ſome other metallic matters: in this laſt ſtate, it is ſaid to be mineralized by theſe ſeveral ſubſtances.

Fluid mercury is found either in globules or in larger maſſes in earths and ſoft ſtones, and moſt frequently in the cavities and interſtices of its ores. At Ydria in Spain, and in America, it is gathered in the cavities and clifts of rocks. Sometimes too it is found in clay at Almaden, and in beds of chalk in Sicily. Laſtly, it is found among ſilver, and lead ores, as well as mixed with white oxide of arſenic.

M. Sage has diſcovered an ore of mercury in oxide from Ydria in Friuli. It is of a red brown colour, very ſoft and granulated in its fracture: globules of running mercury are ſometimes found in it; it is reducible by heat without addition. Mr Kirwan conſiders it as a combination of oxide of mercury with the carbonic acid. One hundred parts of this ore afford 91 of mercury.

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In the year 1776, Mr Woulfe found, at Obermuſchel in the Duchy of Deux-Ponts, an ore of mercury in cryſtals, ponderous, ſparry, white, yellow, or greeniſh, which, on aſſaying it with alkalis, he found to contain both ſulphuric and muriatic acid: it is a compound of ſulphate of mercury with corroſive mercurial muriate. M. Sage affirms it to contain 86 parts of mercury to the hundred weight. The ſame chemiſt deſcribes a brown corneous ore of mercury found in Carinthia.

In nature, mercury is oftenеſt combined with ſulphur. The compound which it then forms is called *cinnabar*. This mineral ſubſtance is red, and has not in the ſmalleſt degree a metallic appearance; becauſe, though the proportion of the ſulphur be very ſmall, yet the two bodies are very completely combined together. Cinnabar is found in the Duchy of Deux-Ponts, in the Palatinate, in Hungary, in Friuli, at Almaden in Spain, and in South America, where it chiefly abounds at Guamanga in Peru. It is ſometimes in compact maſſes, varying in colour from a pale to a deep and blackiſh red; ſometimes in tranſparent ruby-coloured cryſtals; and often in a ſort of ſcales or foliated plates. When in a very bright red powder it is called *native vermilion*, or *cinnabar in flowers*. Laſtly, it is found in various countries in ſulphate of lime, and mixed with iron, pyrites, and ſilver.

Mr Cronſtedt, in his mineralogy, ſpeaks of an ore of mercury in which that ſubſtance is combined with ſulphur and copper. That ore is of a blackiſh grey colour, brittle, and ponderous; its fracture is vitreous, and

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it decrepitates when expoſed to fire. It is found at Muſchel-Landſberg.

The ſame mineralogiſt affirms, that mercury has been often found amalgamated with virgin ſilver in the ore of Sahlberg in Sweden. M. Romé de Lille has in his cabinet a ſpecimen which he thinks to be of this kind.

M. Monnet, in his ſyſtem of mineralogy, ſpeaks of an ore brought from Dauphiny in the year 1768, by M. de Montigny, which contains mercury, ſulphur, arſenic, cobalt, iron, and ſilver. He has found it to contain in the hundred weight, a pound of mercury and three or four ounces of ſilver.

From this ſhort account of mercury, as it exiſts in the interior parts of the earth, it appears that all its ores may be arranged under the following varieties.

State I. Native mercury.

In earths and ſtones, but oftener in its own ores.

State II. Native oxide of mercury.

State III. Native ſulphate and muriate of mercury.

State IV. Mercury mineralized by ſulphur; cinnabar.

Varieties.

Varieties.

1. Tranſparent cinnabar, of a red colour, and cryſtallized in very ſhort triangular priſms, terminating in triangular pyramids.
2. Tranſparent red cinnabar in octohædral cryſtals, conſiſting of two triangular pyramids, joined at the bottom, and truncated.
3. Solid compact cinnabar, either of a brown red or a clear red colour. It is ſometimes in leaves.
4. Red cinnabar, arranged in ſtriæ, on a ſtony gangue, or on ſolid cinnabar. It is ſometimes needled, like cobalt.
5. Cinnabar in flowers, native vermilion. This cinnabar is of a ſparkling red colour reſembling ſattin, and adhering to various gangues in the form of a very fine powder; ſometimes it is cryſtallized in very ſmall needles, and it is then very like the laſt of the foregoing varieties.

State V. Mercury combined with ſulphur and copper: Cronſtedt's black vitreous ore of mercury.

State VI. Mercury mixed with ſulphur, arſenic, cobalt, iron, and ſilver.

State VII. Mercury mixed with ſilver: native amalgam of ſilver.

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In order to know the nature of an ore containing mercury, it muſt be pounded and mixed with lime, alkalis, &c. placed on a warm brick, and covered with a bell-glaſs; the mercury is then reduced to vapours, and again condenſed on the ſides of the glaſs. If it be wiſhed to know the quantity of the mercury which the ore contains, then after being pulverized and waſhed, it is diſtilled with ſome matters capable of combining with the ſulphur, and ſo diſengaging the mercury. Water is previouſly put into the receiver, and the mercury falls under the water. By weighing the ore exactly before aſſaying it, and afterwards the mercury obtained by diſtillation, it is known what quantity of the metal the ore can afford.

Virgin mercury is eaſily ſeparated by grinding down the ſtones with which it is mixed, and diluting them in water. The metal is then precipitated, and the earth mixes with the water. In this manner is the mercury extracted from the ores of Ydria in Friuli.

Cinnabar is never roaſted; becauſe, as it is volatile, it would be diſſipated by fire. But in nature, it is almoſt always mixed with a calcareous or a martial ſubſtance, which contributes as an intermedium to its decompoſition with the help of fire.

Anthony de Juſſieu has given, in the Memoirs of the Academy for the year 1719, a deſcription of the proceſs by which mercury is extracted from cinnabar at Almaden in Spain. That ore contains iron with a ſmall portion of calcareous ſtone. It is put into furnaces of the form of a reverberating furnace; the furnaces are heated by combuſtible matters put into the aſh-pan. The furnace has no appertures but eight holes with which it is perforated

ted behind. To each of theſe holes a line of aludels is fitted; the laſt of which joins a ſmall building at a pretty conſiderable diſtance from the furnace. Between the furnace and the ſtructure where the rows terminate there is a ſmall terraſs on a level with the apertures of the furnace and the building. That terrace conſiſts of two inclined planes, which ſupport the aludels. If the aludels be any where ſo unſkilfully joined as to ſuffer the mercury to eſcape, it is collected at the junction of the inclined planes of the terrace. When the fire is applied to the cinnabar, the iron and the calcareous ſtone abſorb the ſulphur; the mercury is reduced into vapour, enters the aludels, and paſſes towards the little building. After the diſtillation, all the aludels are conveyed into a ſquare chamber, where they are emptied, and all the mercury collected into a pit in the middle of the chamber, towards which the floor is inclined all around it.

Anthony de Juſſieu obſerves, that cinnabar ore does not give out any exhalation noxious to vegetables, and that the grounds adjoining to the mines of Almaden are very fertile. He has alſo obſerved, that the working of theſe mines is not, as had been thought, injurious to the health of the workmen. Thoſe who work in the interior parts of the mine as ſlaves are the only ſufferers; for the fire which they are obliged to kindle always volatilizes a portion of the mercury, and they are of conſequence continually ſurrounded with mercurial vapours.

M. Sage, in the Memoirs of the Academy for the year 1776, has deſcribed the proceſs by which mercury is extracted from cinnabar in the Palatinate. The furnace is a gallery containing forty-eight retorts

of caſt iron, each an inch in thickneſs and three feet nine inches in length, containing about ſixty pounds of matter. Theſe retorts are immoveably fixed upon the furnace. A mixture, conſiſting of three parts of ore well pounded, with one part of ſlaked lime, is introduced into them with braſs ladles. It is heated with mineral coal put in at the two ends of the furnace, the ſides of which are ſo perforated with holes as to admit enough of freſh air to make the coals burn. The heat, with the re-action of the lime on the ſulphur, volatilizes the mercury, which is collected into earthen receivers fitted to retorts, and about a third part full of water. This operation takes up about ten or eleven hours.

Mercury obtained from cinnabar is very pure, and contains not a particle of extraneous matter; ſcarce any is to be got ſo pure in commerce. Almoſt all the mercury ſold by merchants is more or leſs mixed with extraneous matters; it has the appearance of being a little tarniſhed, and inſtead of dividing into globules when it runs, it falls into a flat ſurface ſet round with points. The merchants then ſay that *it draws a tail.*

Mercury ſeems to ſuffer no alteration from light. It is one of thoſe fluid matters which are the eaſieſt and the moſt uniformly heated, that is, whoſe dilatation proceeds in the moſt conſtant manner. This has been ſhown to be the caſe by Meſſrs Bucquet and Lavoiſier, in their experiments on the effects of heat on different fluids, read before the Academy of Sciences. This phænomenon ſhows mercury to be the moſt proper fluid for forming accurate thermometers, by nicely indicating the degrees of heat.

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This metallic fluid, when expoſed to fire in cloſe veſſels, boils like other fluids. This property is not peculiar to it; ſilver, gold, and moſt other metals diſplay the ſame phænomenon. It is true, that as mercury is more fuſible than any other metal, it boils quicker, and continues to boil longer after being red-hot. Ebullition is nothing but the paſſing of a body from a liquid to a vaporous ſtate. This vapour of mercury, which ſoon becomes very apparent in the form of a white ſmoke, and obſcures the tranſparency of the veſſels into which it is received, is condenſed by cold into drops of liquid mercury; which, when the diſtillation has been carefully performed, are found to have ſuffered no loſs nor alteration. Mercury is therefore a very volatile ſubſtance, which may be diſtilled like water, and in this property it bears a near relation to the brittle ſemi-metals.

Boerhaave diſtilled the ſame quantity of mercury 500 times ſucceſſively, without effecting any alteration upon it; only it appeared to become more ſparkling, more ponderous, and more fluid; which might be owing to its being rendered more pure by diſtillation. He obtained a ſmall quantity of grey powder, which appeared to be mercury very much attenuated, and became again fluid and brilliant on being triturated in a mortar. This was black oxide of mercury; and its production muſt have been owing to air contained in the diſtillatory apparatus.

Diſtillation is a method for purifying mercury, and ſeparating from it the fixed metals by which it is uſually altered as it appears in commerce. The extraneous metal is found in the retort, forming in ſome places a brilliant, and in others a blackiſh cruſt. By weighing

this reſidue, we learn what quantity of matter altered the mercury.

The extraordinary gravity of mercury has induced chemiſts to think that it contains a large proportion of the pure earthy principle or vitrifiable earth. But when that principle predominates in any body, it renders it ſolid; and inſtead of being ſolid, mercury is very fuſible: the earthy principle is in an eminent degree fixed, but mercury very volatile. Beccher, obſerving this oppoſition between the qualities of mercury and thoſe of vitrifiable earth, was induced to allow in this fluid the exiſtence of a peculiar earth, to which he gave the name of *mercurial*, aſcribing to it both gravity and volatility. Mercury was then, according to that chemiſt, a compound of three earths, vitrifiable, inflammable, and mercurial. But no perſon has as yet demonſtrated the exiſtence of the latter in any body, and the opinion is therefore to be conſidered as an aſſertion deſtitute of proof. Mercury appears to me to be like other metallic ſubſtances, a peculiar combuſtible body, the principles of which have not yet been ſeparated. As to the vitrifiable earth, the properties of which we examined in the beginning of this work, we do not think that we can admit its exiſtence in mercury any more than in the other metals, becauſe no ſuch principle is ever extracted from it. What Beccher and Stahl diſtinguiſhed by that appellation in mercury and other metallic ſubſtances, is very far from being a ſimple earthy matter, as we ſhowed when ſpeaking of metallic oxides in general.

Mercury in vapours has a conſiderable expanſive force, and is capable of producing lively exploſions when

when attempts are made to confine it. Hellot related to the Academy, that a certain perſon, wiſhing to fix mercury, put a quantity of it into an iron ball, well ſoldered together, and threw the ball into the middle of an hot furnace. But no ſooner was it red hot than the mercury burſt out and eſcaped with a conſiderable noiſe. M. Baumé relates, in his *Experimental Chemiſtry*, a fact nearly ſimilar, to which Geoffroy the apothecary was witneſs.

Mercury is much more ſuſceptible of calcination by the contact of air and of many other bodies, than it has till very lately been thought to be. A blackiſh grey pellicle is inceſſantly forming on its ſurface, which is a true mercurial oxide.

When heated with acceſs of air, this metal changes in a few days into an earthy powder, which is red, brilliant, and diſpoſed in ſmall ſcales. This powder has nothing of a metallic aſpect, and is really oxide of mercury. The alchemiſts thought that mercury was fixed in this operation, and therefore gave the powder the improper name of *precipitate per ſe*. As mercury, tho' very volatile, yet needs the concourſe of air in order that it may be calcined, a pretty convenient inſtrument, called *Boyle's hell*, has been contrived for the purpoſe. It is a very large broad cryſtal bottle; a quantity of mercury is incloſed in it; and as it forms a very thin layer, it of conſequence exhibits an extenſive ſurface. The ſtopper, which exactly fits the mouth of the bottle, is a cryſtal cylinder with a capillary pipe. The bottle is placed on a ſand-bath, and heated till the mercury boil. The aperture of the cylinder is of ſuch a ſize as to admit the air without ſuffering the mercury to eſcape.

After digeſting it in this manner for ſeveral months, the oxide formed on the ſurface of the mercury is ſeparated. Its ſeparation is effected by putting the whole upon a piece of thick cloth, and preſſing it till the mercury paſs through, leaving the oxide upon the cloth. A flat-bottomed matraſs is equally proper for the purpoſe. A quantity of mercury ſufficient to form a thin ſtratum is poured into it: the neck of the matraſs is drawn out by means of a lamp into a capillar pipe, and the point broken off. This method, which we owe to M. Baumé, affords a veſſel more proper for reducing mercury to an oxide, as it contains more air; it may alſo be heated with more eaſe and at leſs expence than *Boyle's bell*, and is not ſo eaſily broken. In order that this experiment may ſucceed, the mercury muſt be night and day for ſeveral months expoſed to an heat ſufficient to make it boil gently. By placing a number of matraſſes on the ſame ſand bath, a greater quantity of precipitate *per ſe*, or red oxide of mercury, is obtained, and a certain quantity of it may even be prepared in fifteen or twenty days.

The precipitate *per ſe* is a true oxide of mercury, or a combination of this metallic ſubſtance with oxigene, which it gradually attracts from the atmoſphere. What proves this in a convincing manner is, 1. That mercury can never be reduced into precipitate *per ſe*, without air: 2. That vital air is neceſſary to the formation of this compound; none of the various gaſes can contribute to the oxidation of mercury: 3. That mercury in this inſtance gains an increaſe of weight; 4. That when the precipitate *per ſe* is heated in cloſe veſſels, it is entirely reduced to running mercury, giving out at

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the time a large quantity of elaſtic fluid, in which combuſtible bodies burn four times as quick as in common air. The exiſtence of this fluid was firſt obſerved by Dr Prieſtley; he gave it the denomination of *dephlogiſticated air*; we call it *oxigenous gas* or vital air. Mercury, on being thus reduced, loſes the increaſe of weight which it had acquired by being calcined.

M. Lavoiſier, from conſidering the laſt of theſe facts, together with the other phænomena of calcination, indicating air to be neceſſary to and conſumed during that operation, has inferred, by an analogy equally fair and probable with any other in phyſics, that metallic oxides are combinations of the metals with the oxigenous part of air. As the *precipitate per ſe* may be eaſily analyſed by heat into two principles, pure viral air and running mercury, this inſtance contributes greatly to illuſtrate and eſtabliſh the pneumatic theory. It may be eaſily underſtood in what manner the baſe of vital air, or oxigene fixed in mercury, diſengages itſelf on regaining its elaſticity by means of heat. Thus to reduce red oxide of mercury, it muſt be heated in very cloſe veſſels: if air be admitted, it remains ſtill in the ſtate of oxide; becauſe it always finds in the atmoſphere a body with which it is capable of uniting; the only body which poſſeſſes the power of calcining it. This is what induced M. Baumé to maintain that the *precipitate per ſe* was not reducible, but, on the contrary, was ſublimed in reddiſh ruby-coloured cryſtals: while M. Cadet has aſſerted that all *precipitates per ſe* are equally reducible into running mercury. Macquer has proved, by an ingenious and natural account of the facts, that each of theſe chemiſts had good reaſon for what he advanced;

vanced; and that when oxide of mercury is heated with concourſe of air, it is entirely ſublimated, and may even be melted into a glaſs of a moſt beautiful red colour; as has been obſerved by Mr Keir, a learned Scotch chemiſt, in his tranſlation of the Chemical Dictionary; whereas this ſame oxide, which is ſublimated when expoſed to the contact of air, is reduced to running mercury, and gives out vital air when urged with an intenſe heat in cloſe veſſels.

As the brilliancy is ſullied by particles of duſt depoſited on its ſurface by the air, it has received the name of *the loadſtone of duſt*: But it appears that all bodies poſſeſs the ſame property; only the ſuperior luſtre of mercury renders it more obſervable in that metal. Beſides, mercury ſuffers no alteration from the duſt which it thus attracts; and on being filtrated through a piece of goat-ſkin to ſeparate thoſe extraneous particles, it recovers all its luſtre.

Mercury appears not liable to ſolution in water: Phyſicians, however, are in uſe to hang a bag filled with mercury in ptiſans to be given for worms,—while they are boiling. We are even aſſured, that experience has evinced the good effects of this practice: Lemery has proved, that mercury loſes nothing of its weight in this decoction. Perhaps a principle analagous to ſmell may on that occaſion exhale from this metal, ſo ſubtle and fugitive, that its weight cannot be diſtinguiſhed, and may communicate an anthelmintic virtue to the water.

Mercury is not more diſpoſed to unite with earths than the other metallic ſubſtances. Its red oxide, or

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precipitate per ſe, might be fixed in glaſſes, and colour them; as is obſerved of the oxide of arſenic.

We know not in what manner barytes, magneſia, lime, and the alkalis act upon mercury.

The ſulphuric acid acts not upon this metallic ſubſtance unleſs when concentrated. To effect this ſolution, put into a glaſs retort one part of mercury, and pour upon it a part and an half of concentrated ſulphuric acid. Let this mixture be heated; a lively effervescence is gradually raiſed; the ſurface of the mercury becomes white, and a powder of the ſame colour is ſeparated, and being diſperſed through the acid, renders it turbid. A conſiderable quantity of ſulphureous gas is diſengaged, and may be collected above mercury. This, as we have ſeen, when ſpeaking of the ſulphuric acid, is the proceſs by which this gas is uſually obtained. There paſſes at the ſame time a portion of water, containing ſulphureous acid gas. When the diſtillation is continued till no more of the ſulphureous acid can be produced, there is then found in the bottom of the retort a white, opaque, and very cauſtic maſs, which weighs one third more than the mercury from which it is produced, and attracts a little moiſture from the atmoſphere. The greateſt part of this maſs is an oxide of mercury, which is combined with a ſmall portion of ſulphuric acid. This matter has been remarked by Kunckel, Macquer, and Bucquet, to be in its nature pretty much fixed. The ſulphuric acid is decompoſed by a double elective attraction: the mercury being a combuſtible ſubſtance combines with the oxigene of the acid, while the heat diſengages the ſulphureous gas and the water. The

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metal is then in the ſtate of an oxide, and muſt of conſequence be much more fixed than running mercury.

A part of this ſulphuric mercurial maſs is diſſolved in water. The fluid, when liberally poured upon it, dilutes the maſs, and, if cold, cauſes it to precipitate a white powder: if the water employed be boiling, the powder takes a beautiful bright yellow colour; and the hotter the water, and the greater the quantity of it poured on the maſs, ſo much the more lively is the colour which the powder aſſumes. The moſt ancient name of this matter was *turbith mineral*, or *yellow precipitate*: we call it yellow mercurial oxide. The water in which it has been waſhed is decanted off; boiling water is again poured upon it, and it now acquires a brighter yellow colour. A third waſhing purifies it from all remains of the ſulphuric acid. It is now deſtitute of taſte; and when urged with fire in a retort, it firſt becomes of a deeper colour, and is afterwards reduced to running mercury, giving out at the ſame time a conſiderable quantity of vital air. Kunckel mentions this reduction. It ſucceeded with Meſſrs Monnet, Bucquet, and Lavoiſier, who traced it through all its circumſtances. I have repeated it ſeveral times with ſucceſs. It proves, as we have already ſeen, that the ſulphuric acid conſiſts of ſulphur, oxigene, and water; but a pretty ſtrong fire is requiſite to reduce this oxide. Perhaps the reaſon why M. Baumé did not obtain running mercury, which has induced him to aſſert that this yellow oxide does not reſume a metallic form unleſs ſome combuſtible ſubſtance be added, was his not having applied it to a ſufficient heat. By continuing to heat the mercurial ſulphuric maſs in the ſame retort

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in which it was diſſolved, without diluting or waſhing it to carry off the acid, we likewiſe decompoſe the oxide: it is reduced to running mercury when the oxigene which it had attracted from the ſulphuric acid acquires elaſticity, and becomes of conſequence vital air by combining with heat and light.

The water poured on the white ſulphuric mercurial maſs, receives that portion of the acid which is not decompoſed, but remains in the maſs. But as oxide of mercury is ſoluble in the ſulphuric acid, that ſaline ſubſtance always carries off with it ſo much of the oxide; and the ſubſtance which remains diſſolved in the water after the reduction is therefore true ſulphate of mercury. When evaporated by a ſtrong heat, it depoſites that ſalt in ſmall needles; the form of which cannot be determined, becauſe they are ſoft and very liable to deliquiate. If boiling water be caſt on thoſe cryſtals of ſulphate of mercury, they become yellow and return to the ſtate of mercurial oxide, the water ſeparating the acid and leaving the oxide pure. The ſame thing happens when, after having evaporated the firſt lixivium of the mercurial maſs by an intenſe heat, we, inſtead of cryſtallizing, dilute it in a large quantity of boiling water: it precipitates a yellow powder which is a true oxide. If cold water be uſed, the precipitate is white; but by pouring boiling water on the white precipitate we may render it yellow. We can likewiſe at pleaſure render the ſolution of mercurial oxide decompoſable or not decompoſable in water. All that is requiſite for this purpoſe is to evaporate the oxide by a violent heat, or to make the acid receive as much of the mercurial oxide as it is capable of diſſolving: theſe two bodies are then

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eaſily ſeparated by water. On adding a little of the acid, the fluid ceaſes to precipitate it. I received full conviction of this fact by diſſolving *turbith mineral* well waſhed in the weak ſulphuric acid. This ſolution not being overcharged with mercurial oxide, is not precipitated by water. But if the acid be charged with as much as it can diſſolve with the help of heat, which happens when the oxide is added till it refuſe to diſſolve it; ſuch a ſolution, on being poured into cold water, forms a white precipitate, and a yellow precipitate when poured into hot water. If a little ſulphuric acid be added to it when in this ſtate, it ceaſes to yield a precipitate. The white mercurial oxide depoſited by ſulphate of mercury ſuperſaturated with mercury, when poured into cold water is very ſoluble: we can make it diſappear by adding ſulphuric acid to the mixture.

Sulphate of mercury may be decompoſed by magneſia and lime, which cauſe it yield to a yellow precipitate. The fixed alkalis ſeparate from it a yellow oxide nearly of the ſame colour: It is to be obſerved, that theſe precipitates of mercury vary in colour according to the ſtate of the ſolution and the ſubſtance by which they are precipitated; the quantity varies too. A ſaturated ſolution gives the moſt copious precipitate. Again, if a ſolution not ſaturated with mercury be decompoſed, each flake of the oxide ſeparated by the firſt drops of the precipitant matters is again diſſolved by the exceſs of acid. When this exceſs of acid is ſaturated, the precipitate is permanent. All theſe mercurial oxides precipitated by alkaline ſubſtances, may be reduced by themſelves in cloſe veſſels.

Ammoniac does not precipitate ſulphate of mercury with an exceſs of acid: but forms with it a triple ſalt, or ammoniaco-mercurial ſulphate. When the ſulphate

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of mercury is ſufficiently neutralized, and without exceſs of acid, it ſeparates but a ſmall portion of the black oxide, which it renders reducible by the contact of light alone; and it forms a triple ſalt with the greater part of the ſulphate of mercury.

Mercury decompoſes the nitric acid with the greateſt rapidity. The ſolution is effected cold, and with more or leſs activity, according to the ſtate of the acid. Common aquafortis acts upon mercury without giving out any great quantity of red vapour. When a little of the fuming nitrous acid is added, or the mixture heated, the re-action of the matters is then very rapid, a very large quantity of nitrous gas is diſengaged, and the mercury reduced to oxide remains in ſolution. The liquor is greeniſh, but loſes that colour at the end of a certain time. By this proceſs, the nitric acid may be cauſed to receive a quantity of mercury equal to itſelf in weight. Bergman has obſerved, in his Diſſertation on the Analyſis of Waters, that nitrous ſolutions of mercury differ from one another according to the manner in which they are prepared. That which has been effected cold, and without the diſengagement of any great quantity of red vapour, is not decompoſable by diſtilled water; but if the ſolution have been promoted by heat, and have given out a conſiderable quantity of nitrous gas, it will then be liable to precipitation by water, and cannot be employed in analizing waters with any certainty of its effects; as we ſhall ſhow when ſpeaking of mineral waters. I take this phænomenon to be owing to the ſame cauſe in the nitrous ſolutions as in the ſolution by the ſulphuric acid. The nitric acid may, with the help of heat, be ſuperſaturated with oxide of mercury, which it holds ſuſpended,

pended. if we may be allowed the expreſſion. This ſolution, with an exceſs of mercury, may be precipitated by diſtilled water, which changes the denſity of the liquor, and diminiſhes the adherence of the mercurial oxide to the nitric acid. The precipitate is therefore a genuine oxide, which becomes very yellow if the ſuperſaturated ſolution be poured into boiling water, but white when poured into cold water. It may be inſtantly coloured by waſhing it in hot water. Again, as the cold ſolution contains only nitrate of mercury without exceſs of oxide, heat being requiſite to ſuperſaturate the acid with the oxide, diſtilled water cannot therefore precipitate it. I am reduced to think this by a fact which I have often obſerved; it is that the ſame mercurial ſolution may be at pleaſure rendered decompoſable or not decompoſable in water, by adding alternately mercury and acid, ſo as to make it paſs from the one ſtate to the other. All that is requiſite for that is to diſſolve mercury cold in the nitric acid, ſuffering the acid to receive as much mercury as poſſible. This ſolution is not decompoſable in water, though it gives out nitrous gas. On adding mercury till it be ſaturated with as much as it can diſſolve with the help of heat, it is rendered ſuſceptible of precipitation by water. The ſame theory very well explains why a nitrous ſolution, not liable to be precipitated by water, becomes ſo when heated. Heat diſengages nitrous gas; and that can never be effected without deſtroying a portion of the acid: the proportion of the mercurial oxide to the acid then becomes greater: it is no longer combined with the mercurial nitrate; but only adheres to it, and is ſo ſuſpended in it that it may be eaſily precipitated

precipitated by water. I am certain that the precipitate which ſolutions of mercury yoild by water is only an exceſs of oxide; and that the ſolution, after giving ſuch a precipitate, ſtill retains a portion of true nitrate of mercury, which may be decompoſed by alkalies in the ſame manner as the ſulphuric mercurial mafs [illegible] in order to the preparation of *turbith* mineral. This portion of nitrate of mercury may even be cryſtallized. The exceſs of mercurial oxide which renders the nitric ſolutions ſuſceptible of decompoſition by water, is attended with another circumſtance which promotes that decompoſition. The oxide is ſo highly calcined or oxigenated as to have but little adheſion to the nitric acid.

The ſolution of mercury in the nitric acid is exceedingly cauſtic; it corrodes and deſtroys animal organs. When it falls on the ſkin, it produces deep purple ſpots, which at a little diſtance appear black. Theſe continue till the epidermis fall off in ſcales. It is uſed in ſurgery as a powerful eſcharotic, under the name of *mercurial water*.

The ſolution of mercury in the nitric acid affords cryſtals, which differ in form, according to the ſtate of the ſolution and the circumſtances of the cryſtallization. On obſerving theſe varieties carefully, I diſtinguiſhed four kinds of them very diſtinct from each other, which I ſhall deſcribe.

1. A cold ſolution affords by ſpontaneous evaporation for ſeveral months very regular tranſparent cryſtals. M. Romé de Lille has deſcribed them very accurately. They are flat ſolid figures with fourteen ſides, formed by the junction of two tetrahædral pyramids,

mids, cut very near the baſe, and truncated at the four angles which reſult from the junction of the pyramids.

2. If the ſame cold ſolution be evaporated by heat and left to cool, it depoſites at the end of four-and-twenty hours a kind of acute priſms, ſtriated obliquely acroſs their length, which are formed of ſmall plates covering each other like tiles, in the manner which botaniſts call *imbricatim*. On a near examination of the elements of thoſe irregular priſms, I perceived the plates to be ſolids with fourteen facets, reſembling the cryſtals obtained by ſpontaneous evaporation, but ſmaller and more irregular.

3. A nitric ſolution effected by means of a moderate and well-managed heat gives, by cooling, cryſtals in very long and very acute flat needles, ſtriated lengthwiſe. Theſe are the cryſtals moſt commonly obtained from this ſolution; and they have been deſcribed by a great many chemiſts, by Macquer, Rouelle, Baumé, &c.

4. Laſtly, If this ſolution be heated till it become decompoſable by water, it is then uſually formed into an irregular white maſs, reſembling the ſulphuric maſs. I have ſometimes ſeen, on that occaſion, a confuſed maſs of very long ſlender, flexile needles, gloſſy like ſattin, moved about with the motion of the liquor: they perfectly reſembled the brilliant, ſilvered dendrites, which I have often obſerved on the ſides of bottles containing *acetite of potaſh*, or *foliated earth of tartar*. It is proper to add, that this laſt ſolution of mercury gives irregular confuſed cryſtals, or ſhapeleſs maſſes, only becauſe it contains an exceſs of the metallic oxide, and

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may therefore be rendered ſuſceptible of regular cryſtallization by adding more of the acid.

Theſe ſeveral nitrates of mercury exhibit nearly the ſame appearances. They are very cauſtic, and corrode the ſkin as well as their ſolutions; they detonize when put on burning coals. With reſpect to this property, it is to be obſerved, that it belongs in a much more eminent degree to the moſt regular cryſtals with fourteen faces, than to thoſe which are in the form of ſmall needles; and that the white maſs precipitated from the ſolution, after it has been expoſed to a ſtrong heat, is entirely deſtitute of it. The detonation of nitrate of mercury is ſcarce obſervable in newly formed cryſtals; to render it more ſenſible, the nitrate muſt be left to dry for ſome time on blotting paper. If the cryſtals be then put on a burning coal, they melt, become black, and extinguiſh the flame of that part of the coal on which they lie. But their edges being dried, throw out little reddiſh ſparks with a noiſe ſimilar to a faint decrepitation. When dry they emit a more lively whitiſh flame; but it very ſoon ceaſes.

Mercurial nitrate melts when heated in a crucible; very thick red vapours then exhale from it: as it loſes its water and its nitrous gas, it aſſumes a deep yellow colour, which changes firſt to an orange, and afterwards to a bright red: in this ſtate it has been called *red precipitate*. We diſtinguiſh it by the name of *red oxide of mercury by the nitric acid*. It ſhould be made in matraſſes with a moderate heat when it is meant to be employed in ſurgery as a cauſtic, in order that it may retain a portion of the acid to which it owes its corroſive powers: But when it is made very hot, it be-

comes merely oxide of mercury, formed by the combination of that metal with the oxigene of the nitric acid. Nitrate of mercury diſtilled in a retort, affords, in the firſt place, an acidulous phlegm and nitrous gas: it is now in the ſtate of red precipitate. On being made very hot, it gives out a conſiderable quantity of vital air mixed with a little azotic gas; and the mercury is ſublimated in a metallic form. This experiment made by M. Lavoiſier with the utmoſt accuracy, led him to the diſcovery of the component principles of the nitric acid; as we have mentioned in our hiſtory of that acid.

Nitrate of mercury becomes yellowiſh, and is very ſlowly decompoſed in the air. It diſſolves readily enough in diſtilled water, is more ſoluble in boiling than in cold water, and cryſtallizes by cooling. When this ſalt is diſſolved in water, part of it is precipitated without being diſſolved, and acquires a yellowiſh colour, M. Monnet calls that matter *nitrous turbith*; and obſerves, that a good deal of it may be obtained by waſhing a nitric mercurial maſs evaporated to dryneſs, as is done in preparing *red precipitate*. When nitrate of mercury is to be entirely diſſolved, diſtilled water muſt be uſed, and aquafortis poured into it till the precipitate diſappear. I have obſerved, that when boiling water is poured on very pure nitrate of mercury, the ſalt becomes inſtantly yellow, and affords an oxide of a deeper colour, which on being expoſed to fire, becomes red much ſooner than that which owes its formation to the ſulphuric acid. Yellow oxide of mercury by the nitric acid, is generally more complete-

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ly calcined than that which is prepared with the ſulphuric acid: the reaſon of which is, as we have already obſerved of other combuſtible ſubſtances, that the oxigene is more eaſily diſengaged from the nitric than from the ſulphuric acid. This is what renders the nitric acid more decompoſable than the ſulphuric acid.

Barytes, magneſia, lime, and the alkalis, decompoſe nitrate of mercury, and precipitate the mercury in the ſtate of oxide. Theſe precipitates vary in colour, gravity, and quantity, according to the ſtate of the ſolution. The cauſtic fixed alkalis form a yellow precipitate, which is more or leſs brown or brick-coloured according to their cauſticity. Ammoniac cauſes the nitric ſolution of mercury in a good condition, that is, when water cannot decompoſe it, to yield a ſlate-grey precipitate; whereas the ſame ſalt produces a white ſediment in a ſaturated ſolution of mercury liable to be precipitated by water: theſe diſtinctions have been very accurately obſerved by Bergman. Theſe precipitates are merely oxides of mercury more or leſs calcined. They are all reducible without addition, by heat, in cloſe veſſels; and when reduced, they give out pure air. Thoſe which have been precipitated by alkaline carbonates, afford a certain quantity of carbonic acid by the action of heat. Thoſe which have not been precipitated by carbonates, but only expoſed to the contact of atmoſpheric air, diſplay the ſame phenomenon, for they abſorb that acid from the atmoſphere; a property which is common to all oxides of mercury, and even to thoſe of ſeveral other metals.

Oxides of mercury precipitated from ſolutions by alkaline intermedia, poſſeſs a peculiarity which has been diſcovered by M. Bayen, and is worthy of being here taken notice of. They detonize like gun-powder when expoſed in an iron ſpoon to a gradual heat, after being triturated with flowers of ſulphur in the proportion of half a drachm to ſix grains. After the detonation, there remains a violet-coloured powder which may be ſublimated into cinnabar.

The ſulphuric acid, and the ſalts into which it enters, are alſo capable of decompoſing nitrate of mercury; for this acid has a greater affinity than the nitric acid with mercury. If a portion of ſulphuric acid, or of a ſolution of ſulphate of potaſh, ſulphate of ſoda, &c. and in general of any ſulphuric ſalt, be poured into a nitric ſolution of mercury, a whitiſh precipitate is formed, if the ſolution be not ſaturated; which inclines more to yellow in proportion as the mercurial nitrate contains leſs acid, and more mercurial oxide. This precipitate is either ſulphate of mercury or yellow oxide. M. Bayen has obſerved that it always retains a little nitric acid.

The muriatic acid does not act in a ſenſible degree on mercury; although it has a greater affinity with the oxide of this metal than any of the other acids. It combines with the oxide to form a peculiar ſalt. This combination takes place whenever the muriatic acid is brought into contact with that oxide, and the oxide divided into very minute particles. If a little muriatic acid be poured on a nitric ſolution of mercury, the acid ſeizes the oxide of the metal, and forms with it a ſalt which is precipitated in a kind of whitiſh coagulum, called

called *white precipitate.* Muriatic ſalts with alkaline or ſalino-terreous baſes, produce preciſely the ſame effects, and form beſides nitric ſalts, differing according to their baſes. But it is of importance to obſerve concerning this precipitation, that it does not take place if the oxigenated muriatic acid be employed; for though that acid attracts the oxide of mercury from the nitric acid, the ſalt which it forms with it is very ſoluble in water; whereas that which the common muriatic acid forms with this acid is not at all ſoluble in water.

This acid has likewiſe a greater affinity with oxide of mercury than the ſulphuric acid has; and when poured into ſolutions of this metal with the ſulphuric acid, it produces precipitate in the ſame manner as in ſolutions of mercury with the nitric acid. The compound of the muriatic acid with oxide of mercury is capable, as above obſerved, of two different ſtates, according as the acid is ſimple or oxigenated: with the oxigenated muriatic acid it conſtitutes corroſive mercurial muriate; with the ſimple muriatic acid, it is mild mercurial muriate.

There are ſeveral ways of preparing *corroſive ſublimate*, or corroſive mercurial muriate. The moſt common way is, by mixing equal parts of dried mercurial nitrate, decrepitated muriate of ſoda, and calcined or white ſulphate of iron or *martial vitriol*; putting this mixture into a matraſs, of which two thirds muſt remain empty; immerſing the mixture into a ſand-bath, and heating it gradually till its bottom be made red hot. The ſulphuric diſengages the muriatic acid from the ſoda: the ſoda again ſeparates the nitrous acid

from the mercury, which has robbed it of part of its oxigene; and becomes of conſequence oxigenated muriatic acid: After that, it combines with the oxide of mercury, and forms corroſive mercurial muriate, which is ſublimed into flat pointed cryſtals, that fix on the upper part of the matraſs. The nitric acid is diſperſed in nitrous gas; the reſidue is reddiſh or brown, and contains oxide of iron and ſulphate of ſoda, formed by the combination of the ſulphuric acid with the baſe of the marine ſalt. In Holland, this ſalt is prepared in the great way, by triturating together equal parts of mercury, muriate of ſoda, and ſulphate of iron, and expoſing the mixture to an intenſe heat. In this way of preparing *corroſive ſublimate*, the ſulphuric acid, diſengaged by heat from ſulphate of iron, appears to convert the ſimple into oxigenated muriatic acid; for no other but this laſt acid could diſſolve all the mercury employed on the occaſion. Corroſive mercurial muriate may be likewiſe obtained, by ſublimating a mixture of ſulphate of iron, muriate of ſoda, and mercurial precipitate by fixed alkali, or any other kind of mercurial oxide.

Boulduc has given a very good proceſs for preparing corroſive mercurial muriate: but Spielman remarks, that it was before ſuggeſted by Kunckel in his Chemical Laboratory. It conſiſts in heating in a matraſs equal quantities of ſulphate of mercury and decrepitated muriate of ſoda. Muriate of mercury is volatilized, and what remains is only ſulphate of ſoda. This mode of operation affords very pure corroſive mercurial muriate, whereas that which we get in commerce, and even that which is prepared in the ſmall way

way with ſulphate of iron, always contains ſome mixture of iron. Boulduc's proceſs is both eaſier and leſs expenſive. It likewiſe proves, that the ſulphuric acid poſſeſſes the property of oxigenating the muriatic acid. M. Monnet informs us, that he obtained this ſalt alſo by treating in a retort very dry muriate of ſoda with mercurial oxide, precipitated from the nitrous ſolution of mercury by fixed alkali. In all theſe proceſſes for preparing corroſive mercurial muriate, the operator ſhould beware of breaking the veſſel containing the ſublimate till it be perfectly cool, leſt he ſuffer from the vapours of the ſalt. Laſtly, There is yet another and more expeditious way of preparing corroſive mercurial muriate: it conſiſts in pouring oxigenated muriatic acid into a ſolution of nitrated mercury, and evaporating the mixture ſlowly: when the nitrous acid is diſengaged, the liquor affords, by cooling, cryſtals of corroſive mercurial muriate. There is reaſon to think, that when Scheele's oxigenated muriatic acid becomes better known, apothecaries will prepare corroſive mercurial muriate either by this laſt proceſs or by ſimple ſolution.

Corroſive mercurial muriate is a neutral ſaline ſubſtance, which well merits the attention of chemiſts and phyſicians. It poſſeſſes a number of valuable properties, of which we ſhall give the hiſtory. This ſalt has a very cauſtic taſte. When but the ſmalleſt quantity touches the tongue, it leaves for a long time after a ſtiptic and metallic impreſſion, which is very diſagreeable. This impreſſion extends even to the larynx, ſhutting it ſpaſmodically; and it remains long, particularly

cularly on perſons of very delicate nerves. This ſalt acts in a ſtill more ſenſible manner on the coats of the ſtomach and the viſcera. When ſuffered to act upon them for ſome time, it corrodes them, ſo as to deſtroy their ſubſtance: It is of conſequence one of the ſtrongeſt poiſons known. The cauſticity of corroſive mercurial muriate appears to depend on the ſtate in which the mercury exiſts in the ſalt, as has been very ingeniouſly explained by Macquer. It cannot, as ſome authors have imagined, be aſcribed to the muriatic acid; for the quantity of the mercury is more than three times as much as that of the acid. Accordingly it has been obſerved by Rouelle, that this ſalt communicates rather a green than a red colour to ſyrup of violets. The taſte, too, of corroſive mercurial muriate is much ſtronger than that of the muriatic acid. A perſon may take a drachm of muriatic acid diluted in water, without ſuffering any harm: whereas a few grains of corroſive mercurial muriate taken in the ſame quantity of water are a certain poiſon. Bucquet thought this exceſſive ſapidity to depend on the combination of the two bodies which compoſe this ſalt. One of his ſtrongeſt proofs was drawn from that law of the affinity of compoſition by which it is eſtabliſhed, that compounds poſſeſs new properties entirely different from thoſe of the bodies of which they are compounded.

Corroſive mercurial muriate ſuffers no ſenſible alteration from light. Heat volatilizes and half vitrifies it. When expoſed to a ſtrong heat in the open air, it is diſſipated in a white ſmoke; the effects of which are very energetic, and very noxious to the animal œconomy.

nomy. When heated ſlowly and by degrees, it is ſublimated in a regular cryſtalline form. Its cryſtals are priſms, ſo compreſſed that it is impoſſible to determine the number of their faces. They terminate in very acute points; and have been with good reaſon compared to the blades of poignards thrown very confuſedly together. Fire does not decompoſe this; it ſuffers no alteration from air. It diſſolves in nineteen parts of water, and cryſtallizes by evaporation into flat priſms, very acute at their extremities, reſembling thoſe obtained by ſublimation. The ſpontaneous evaporation of its ſolution afforded both me and M. Lucquet ſeveral times oblique angled parallelopipeds, with their extremities truncated ſlopewiſe. M. Thouvenel has obtained that ſalt cryſtallized in hexahædral priſms, a little compreſſed.

Barytes, magneſia, and lime decompoſe corroſive mercurial muriate, cauſing it to yield a precipitate of oxide of mercury. The *phagedenic water* uſe by ſurgeons as a corroſive, is prepared by caſting half a dram of this ſalt in powder into a pound of lime-water; a yellow precipitate is formed, which renders the liquor turbid, and it is employed before the precipitate ſubſide. The fixed alkalis ſeparate from corroſive mercurial muriate an orange oxide, which when ſuffered to ſettle for ſome time, acquires a deeper colour. Ammoniac cauſes this ſalt to yield a white precipitate; which, however, ſoon aſſumes a ſlate colour.

The acids, and the alkaline neutral ſalts, produce no alteration on corroſive mercurial muriate.

This ſalt contracts an intimate union with ammoniacal muriate; but neither of them is decompoſed. Either by ſublimation, or by cryſtallization, it forms with

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it a very ſingular ſaline compound, which the alchemiſts valued highly, and called *alembroth ſalt*, *ſalt of art*, *ſalt of wiſdom*, *&c.* The ammoniacal muriate renders the corroſive mercurial muriate very ſoluble; for acording to M. Baumé, three ounces of water containing nine drachms of the former ſalt diſſolve five ounces of the latter. This laſt ſolution is effected with the help of heat, and when it cools, the laſt ſubſides into a maſs. With this ſalt a preparation is made up which is called *white precipitate*. It is prepared by caſting into a ſolution of a pound of ammoniacal muriate an equal quantity of corroſive mercurial muriate in powder. When this ſalt is fully diſſolved, a ſolution of carbonate of potaſh is poured into the mixture, and produces a white precipitate: this precipitate is waſhed, formed into little balls, and dried in the air. In this operation the potaſh diſengages the ammoniac; which, in its turn, precipitates the mercury in a white oxide. This precipitate becomes yellow when expoſed to heat, or even to light.

Corroſive mercurial muriate is altered by hydrogenous gas. Sulphur produces no change on it, but alkaline ſulphure decompoſes it as well as the other ſolutions of mercury: the immediate product of this decompoſition is a black precipitate which reſults from the combination of the ſulphur with the mercury. Moſt of the ſemi-metals which we have examined are capable of decompoſing this ſalt: and as each of theſe inſtances of decompoſition is attended with peculiar phænomena, they therefore deſerve to be ſeparately and carefully examined.

When

When two parts of corroſive mercurial muriate, with one of arſenic, are diſtilled by a moderate heat, there paſſes into the receiver a matter of the conſiſtency of oil, and tranſparent, of which one part is very ſoon condenſed into a kind of white jelly, improperly called *corroſive oil*, or *butter of arſenic*. If the heat be continued after this product has paſſed off, running mercury is obtained; and by this proceſs we may attain an accurate knowledge of the principles of corroſive mercurial muriate. Muriate of arſenic does not appear to be ſuſceptible of cryſtallization; it melts by a moderate heat, and its taſte is ſo cauſtic, that it inſtantaneouſly deſtroys our organs. It diſſolves in water, by which it is partly decompoſed: we are ignorant of its other properties. It cannot be obtained with oxide of arſenic; becauſe when that ſemi-metal is already ſaturated with oxigene, it cannot diſengage mercury from its combination with the muriatic acid by abſorbing oxigene.

The effects of nickel, cobalt, and manganeſe, on corroſive mercurial muriate, have not yet been examined. As to biſmuth, antimony, and zinc, thoſe three ſemi-metals decompoſe this ſalt very readily. By diſtilling two parts of corroſive mercurial muriate with one of biſmuth, we obtain a thick fluid ſubſtance, which congeals into a kind of greaſy maſs that melts on being expoſed to heat, and yields a precipitate when plentifully waſhed: in a word, this compound is ſolid muriate of biſmuth. Poli, who has given an account of this proceſs in the Hiſtory of the Academy for the year 1713, tells us, that when this *butter of biſmuth* is ſeveral times ſublimated, there remains in the veſſel a powder coloured

loured like oriental pearls, very ſoft and gluey: He propoſes the uſe of this powder in painting.

When twelve ounces of antimony are completely mixed with two pounds of corroſive mercurial ſublimate, the mixture gives out heat: a circumſtance which proves that theſe two bodies act rapidly on each other. On diſtilling this mixture by a moderate heat, we obtain a thick liquor which is fixed in the receiver, and often even in the neck of the retort, into a white maſs called *butter of antimony*. The quantity of this ſublimated muriate of antimony is commonly ſixteen ounces and a few drachms. The reſidue conſiſts of mercury and a grey powder of antimony, which ſwims on the ſurface of the metallic fluid. On continuing the diſtillation after the muriate of antimony has paſſed into the receiver, and uſing a new balloon, we obtain running mercury; but it is contaminated with a little muriate of antimony, as that ſubſtance cannot be entirely taken away from the neck of the retort. M. Baumé, who has given a good account of this operation, ſays, that by this proceſs twenty-two ounces of running mercury may be obtained, one ounce of antimony in powder mixed with mercury, and ſix drachms twenty-four grains of antimony melted in the retort. The antimony is partly calcined: it affords a red and partly white oxide, which is ſublimed. In this inſtance the antimony is calcined by the oxigene ſeparated from the mercurial oxide, and combines with the muriatic acid to form muriate of antimony. This decompoſition likewiſe takes place when ſulphure of antimony is employed. By diſtilling one part of that mineral in powder with two parts of corroſive mercurial ſublimate, ſublimated muriate of antimony

ny is obtained; but the reſidue, inſtead of containing running mercury, is a combination of mercury with ſulphur. That combination may be ſublimated by a very ſtrong heat into red needles, which are improperly called *cinnabar of antimony*.

Sublimated muriate of antimony, or the combination of the muriatic acid with antimony, is not produced unleſs when the ſemi-metal attracts from the mercury the oxigene which it contains; as has been already obſerved of arſenic. This compound is in a cryſtalline form. It cryſtallizes into very large parallelopipeds. It is ſo cauſtic, that it inſtantly deſtroys our organs, and burns vegetable matters. It is very liable to alteration by the contact of light. It melts with the moſt moderate heat, and becomes fixed by cooling: it is this property which has procured it the name of *butter* of antimony. It readily loſes its whiteneſs, and takes a colour. It may be rectified by diſtillation. It attracts the moiſture of the atmoſphere, by which it is again diſſolved into a thick and ſeemingly oleaginous fluid: in water it is diſſolved only in part; for the greateſt portion of it is decompoſed by that fluid. When ſublimated muriate of antimony is caſt into diſtilled water, it immediately gives a very copious precipitate, which is called *emetic powder*, or *powder of Algaroth*, from the name of an Italian phyſician who uſed it as a medicine. It has likewiſe been improperly called *mercury of life*. This precipitate is an oxide of antimony ſtrongly purgative and emetic, even when given in very ſmall doſes of three grains and an half to the doſe. In order to render it very pure, it muſt be repeatedly waſhed in diſtilled water. It differs in poſſeſſing theſe properties from the other oxides of this

this ſemi-metal, which are far from acting in ſo energetic a manner on the animal œconomy. A portion of this oxide is diſſolved in the water, in which muriate of antimony is waſhed, by means of the acid which mixes with the fluid. We have an opportunity of obſerving this fact on pouring a little alkali into that liquor: a white precipitate is produced in conſiderable abundance; and butter of antimony therefore appears to owe its property of being decompoſable in water to its containing an exceſs of this oxide; and its forming into a ſolid maſs may be attributed to the ſame cauſe. Sublimated muriate of antimony diſſolves with heat and effervescence in the nitric acid. From that ſolution there is diſengaged a large quantity of nitrous gas, which excites a conſiderable emotion in the mixture; the muriate of antimony diſappears, and the liquor appears of a reddiſh yellow colour. This is a ſolution of oxide of antimony in the nitro-muriatic acid. It very ſoon depoſites the oxide of antimony in the form of a powder, and even of a white magma. If the ſolution of muriate of antimony by the nitric acid be evaporated to dryneſs as ſoon as made, it yields a very white oxide: It is diluted with a quantity of the ſame acid equal to its own weight, and again evaporated: the powder is yet a third time mixed with the ſame quantity of nitric acid and evaporated to dryneſs: it is then heated in a crucible, which is kept red hot for about half an hour, and after that ſuffered to cool. The oxide now taken out of the crucible is white above, and roſe-coloured on the under part. The two portions are mixed, and form by their mixture what is called *Bezoar mineral.* Macquer conſiders this medicine as a

perfect

perfect oxide of antimony, and thinks it to be the ſame with *diaphoretic antimony*. Lemery, however, who has given an accurate deſcription of this preparation, adviſes to calcine it till it have ſcarce any acidity; wiſhing it to retain *ſome* acid, which muſt certainly change the properties of the oxide of antimony.

Corroſive mercurial muriate is decompoſed by zinc, as has been aſſerted by Pott, and as I myſelf have found by repeated experiments. If you diſtill in a glaſs retort a mixture conſiſting of two parts of this ſalt with one of zinc in filings, or coarſe powder, a white and ſolid ſalt aſcends from the mixture, and is cryſtallized in ſmall needles joined together in a form reſembling the little bundles of which ſtalactites conſiſt. This muriate of zinc emits a thin ſmoke when it is taken out of the receiver: it melts by a moderate heat; is coloured by inflammable vapours; and laſtly, is partly decompoſed in water like ſublimated muriate of antimony.

The moſt ſingular property which corroſive mercurial muriate exhibits in regard to the alterations which it ſuffers from metallic ſubſtances, as well as the moſt important property which it poſſeſſes, is its power of combining with running mercury. When ſaturated with that metallic fluid it loſes moſt of its properties, particularly its taſte and ſolubility. The old way of producing this combination, was by triturating in a glaſs mortar corroſive mercurial muriate with running mercury, adding the mercury by degrees till it refuſed to unite with the mercurial muriate. Lemery and M. Baumé have obſerved, that the ſalt takes up a quantity of mercury equal to about three fourths of its own weight.

weight. The mixture was then put into ſmall phials, two thirds of each of them being left empty, and ſublimated three times ſucceſſively. Care was taken to ſeparate at each time a white powder, which is found above the ſublimated matter, and is very corroſive. This product is called *ſweet ſublimate*, *mercurius dulcis*, or *aquila alba*: It ought to be called *ſweet mercurial muriate*. Its inſipidity, its cryſtalline form, and its being almoſt abſolutely inſoluble, diſtinguiſh it from corroſive mercurial ſublimate. The cryſtals which it affords by ſlow ſublimation are tetrahædral priſms terminating in four ſided priſms. We often find among them two very long tetrahædral pyramids, joined at the baſe, and forming very acute octohædrons.

The proceſs for preparing ſweet mercury, which we have here deſcribed, is attended with ſeveral inconveniences. To triturate corroſive mercurial muriate with running mercury till the mercury be entirely confounded with the mercurial muriate, is a very tedious and a very difficult taſk. A very minute acrid duſt ariſes from the mixture while it is triturated; and the operator muſt bind a cloth over his mouth and noſe to ſecure himſelf againſt the dangerous effects of that duſt. The mercury is never entirely incorporated with the mercurial muriate; and the ſublimation is very ſlow. M. Baumé adviſes to pour a little water on the matters as they are triturated. That fluid aſſiſts the trituration, and hinders the ſaline duſt from riſing. He likewiſe employs levigation, which contributes greatly to make the mercury incorporate with the ſalt. Laſtly, to make ſure of obtaining mild mercurial muriate without the leaſt

leaſt mixture of corroſive, Zwelfer, Cartheuſer, and M. Baumé propoſe to pour on mild mercurial muriate, after it has been once ſublimated, a quantity of hot water to diſſolve the corroſive muriate, and then dry the ſalt, which is after this found to be much milder than before. M. Cornette, to hinder the volatilization of the corroſive mercurial muriate triturated with the mercury, propoſes to make uſe of nitrate of mercury precipitated by ammoniac, which unites with corroſive mercurial muriate much more readily than running mercury. But as this oxide is not ſo pure as mercury, we cannot depend ſo much on the virtues of the preparation into which it enters. M. Bailleau, an apothecary in Paris, has given the Royal Society of Medicine a proceſs for preparing mild mercurial muriate, without being expoſed to any of thoſe accidents which render the preparation of it in the common way ſo very dangerous. This proceſs conſiſts in forming a paſte with corroſive mercurial ſublimate and water, and triturating it with running mercury. Half an hour's trituration is here ſufficient; becauſe the water contributes to confound the two ſubſtances together. The proceſs ends with digeſting the mixture on a ſand-bath by a moderate heat; the matter changes its original grey colour for white, and forms a very mild mercurial muriate, which needs only to be ſublimated, in order that it may be perfectly pure.

M. Baumé has made ſeveral experiments on mild mercurial muriate. He has ſhown, that it cannot receive an additional quantity of mercury; that it cannot exiſt in a middle ſtate between corroſive and mild mercurial muriate; as where a ſmaller portion of mercury is mix-

ed with the corroſive mercurial muriate than what is requiſite to make it paſs into the ſtate of mild mercurial muriate, a portion of this latter ſalt is formed, in proportion to the quantity of the mercury and the exceſs of the corroſive; and the reſt of the corroſive mercurial muriate is volatilized without ſuffering any alteration of its properties. Theſe two compounds are ſeparable by hot water.

From the reſearches of the ſame chemiſt we learn farther, that it is poſſible to change the mild into corroſive mercurial muriate, by ſublimating it with decrepitated marine ſalt and white calcined ſulphate of iron. In this operation the muriatic acid being diſengaged and oxigenated by the ſulphuric acid, unites with the mercurial oxide of the mild mercury, and converts it into corroſive muriate. M. Baumé is convinced that mild mercurial muriate differs greatly from the corroſive, as it cannot unite with ammoniacal muriate as the corroſive mercurial muriate does in the preparation of *alcmbroth* ſalt, or ammoniaco-mercurial muriate. It is even from the conſideration of its poſſeſſing this property, that he adviſes to waſh mild mercurial muriate with water impregnated with a little ammoniacal muriate, to carry off all the corroſive mercurial muriate which renders that ſalt ſo very ſoluble. Laſtly, he has diſcovered, that at each ſublimation mild mercurial muriate loſes a part of its mercury, and affords of conſequence a certain quantity of corroſive mercurial muriate; ſo that by repeated ſublimation mild mercurial muriate may be entirely changed into corroſive. From this laſt fact it follows, that the medicine, known by the name of *mercurial panacea*, which conſiſts of mild mercurial muriate nine times

ſublimated,

ſublimated, is ſo far from being rendered milder by being ſo often ſublimated, as moſt chemiſts and phyſicians think, that at the end of the proceſs it differs in no reſpect from what it was at firſt. A circumſtance attending the operation may be conſidered as a farther proof of this aſſertion; at each ſublimation a ſmall quantity of white powder which riſes firſt is taken off, which powder is nothing but corroſive mercurial muriate. It is to be obſerved, that there remains in the phials a reddiſh powder when mild mercurial muriate is prepared. It is an oxide of iron produced from the ſulphate of iron, which is employed in preparing the common corroſive mercurial muriate. Part of that oxide aſcends with the ſalt in its ſublimation; nay, the mercurial ſalt in vapour is often found to carry up with it even pieces of glaſs.

Late experiments on the oxigenated muriatic acid render the theory of the formation of mild mercurial muriate much more clear and intelligible than it formerly was. It has of late been proved, that corroſive mercurial muriate is a compound of oxigenated muriatic acid with oxide of mercury, and that mild mercurial muriate is formed by the common muriatic acid with the ſame metallic oxide: or, what amounts to the ſame thing, that in corroſive muriate the oxide is much more calcined than in mild muriate. Thus when running mercury is triturated with corroſive mercurial muriate, the mercury ſeizes the exceſs of oxigene contained in the muriatic acid, or in the former mercurial oxide; and as a larger quantity of mercurial oxide, and that leſs completely calcined, now combines with the ſame quantity of muriatic acid, the nature of the ſalt

is of conſequence altered, and it becomes leſs ſaline, more inſipid, and more inſoluble: in a word, its qualities are weakened in proportion as the quantity of the mercurial oxide is increaſed.

The boracic acid does not diſſolve mercury without an intermedium; but, in the ſtate of oxide, it acts in a very diſcernible manner on this ſemi-metal. Theſe two ſubſtances may be combined by the way of double affinity. When a ſolution of common borax is poured on a nitric ſolution of mercury, a very copious yellow precipitate is produced, which was firſt made known by M. Monnet. In this operation the ſoda of the borax, uniting with the nitric acid, forms nitrate of ſoda; while the boracic acid unites with the mercurial oxide to form an almoſt inſoluble neutral ſalt which is precipitated. The liquor being filtrated and evaporated, affords fine brilliant pellicles of mercurial borate. We muſt, however, obſerve, that the ſalt contains a portion of oxide of mercury not combined with the boracic acid, becauſe there is always an exceſs of ſoda in common borax. To obtain borate of mercury by this proceſs, the borate of ſoda employed muſt be fully neutralized, that is, completely ſaturated with boracic acid. This ſalt, when expoſed to the air, turns ſenſibly green; ammoniacal muriate renders it very ſoluble, and forms with it a compound reſembling ammoniaco-mercurial muriate. Lime-water makes it yield a yellow precipitate; the colour of which changes to a deep red: with potaſh it yields a white precipitate. According to the academicians of Dijon, corroſive mercurial muriate is likewiſe decompoſed by borax, which produces in a ſolution of it a brick-coloured precipitate. Water boiled,

over

over this precipitate becomes of a lacteous appearance on the addition of a fixed alkali; which proves it to contain mercurial borate.

We know not in what manner the fluoric acid acts upon mercury; and we are no less ignorant of the effects which the carbonic acid produces upon it. We know only that water impregnated with this acid never acts upon mercury; though solutions of mercury decomposed by alkaline carbonate afford precipitates very different from those produced by the same salts in a pure caustic state, and mercurial oxide readily absorbs carbonic acid from the atmosphere.

The neutral salts have but very little power of action on mercury. Although this assertion chiefly regards the various sulphuric salts, yet I have remarked, that quicksilver incorporates readily with sulphate of potash.

Mercury does not appear capable of altering ammoniacal muriate by distillation. Bucquet, who made this experiment, has observed, that one part of the salt is not quite sufficient to absorb two parts of mercury, and the mixture gives no ammoniac by distillation. Yet the Count de Gatave had made up with these two substances a medicine to which he gave the name of *tincture of mercury*. Macquer, on examining his process, found it to be perfectly consistent with what he had advanced. It consists in triturating in a marble mortar an ounce of running mercury with four ounces of ammoniacal muriate, moistening the mixture with a little water till the mercury be entirely incorporated with the salt, leaving that matter then exposed to the air for five or six weeks, and shaking it from time to

time. It muſt, at the end of this time, be triturated anew, put in a matraſs upon a ſand-bath with good alcohol ſwimming above the powder to the depth of two inches, and cauſed to boil gently. The alcohol acquires a yellow colour, and appears to contain mercury from its communicating a white colour to a plate of copper. It appears, that in this operation the ammoniac is gradually diſengaged by the mercury, forming of conſequence ammoniaco-mercurial muriate, of which part is diſſolved by the alkali; and that the difference in the quantity of the mercury, and the gentle action which takes place during the maceration, are the cauſes why this experiment gives a reſult different from Bucquet's.

We know not in what manner hydrogenous gas acts upon mercury. Mercury combines very well with ſulphur. When one part of this metallic fluid is triturated with three parts of ſulphur, the mercury is by degrees confounded with the ſulphur; and the reſult is a black powder, black ſulphure of mercury, or *Æthiop's mineral*, the colour of which deepens when it is ſuffered to lie aſide. This combination is produced more quickly when the mercury is mixed with melted ſulphur: on ſhaking that mixture it becomes black, and eaſily takes fire. In order to make it retain its black colour, it muſt be taken out of the fire, the flame muſt be quenched as ſoon as it appears, and the matter ſtirred till it become ſolid, and form into lumps. It is then reduced to powder, and paſſed through a fine ſieve. Black ſulphure of mercury is not the moſt intimate poſſible combination of ſulphur with mercury. When this compound is expoſed to an intenſe heat, it

kindles,

kindles, moſt of the ſulphur burns, and there remains, after that combuſtion, a matter which, when pulverized, takes a violet colour. This powder is put into a matraſs, which is heated till its bottom become red: it is kept for ſeveral hours in that ſtate till the matter be ſublimated. In the upper part of the matraſs there is found after the ſublimation a quantity of artificial cinnabar, or red ſulphure of mercury cryſtallized in needles of a brown red colour. Its colour is more lively, and not ſo deep when it is ſublimated in retorts. The Dutch prepare cinnabar for the arts in the great way. This compound is ſcarce volatile; and of conſequence a very intenſe heat is requiſite to ſublimate it. When much divided by levigation, it takes a bright red colour; and is then called *vermillion*. If heated in open veſſels, the ſulphur, which amounts to one-fourth of the whole quantity, burns by degrees, while the mercury is volatilized. Many ſubſtances have ſuch an affinity with ſulphur as to decompoſe red ſulphure of mercury. Lime and alkalis poſſeſs this property. When they are heated in a retort with this ſulphure, in the proportion of two parts of the ſulphure to one of the lime or alkali, running mercury is obtained, and the reſidue is alkaline or earthy ſulphure. M. Baumé has even obſerved this decompoſition to take place in the humid way, when red ſulphure of mercury is boiled with liquor of fixed alkali. It is remarkable, that the alkali which he employed was not effervescent. Several of the ſemi-metals, ſuch as cobalt, biſmuth, and antimony, likewiſe poſſeſs the property of attracting ſulphur from mercury. We will ſee, that almoſt all the metals, lead, tin, iron, copper, and ſilver, have a greater affinity than

mercury with ſulphur; and of conſequence decompoſe *cinnabar:* they may be therefore uſed indifferently to ſeparate the mercury of that compound. This metallic fluid, when obtained by ſuch a proceſs, is perfectly pure. It is diſtinguiſhed by the name of *mercury revivified from cinnabar.*

Mercury inſtantaneouſly decompoſes alkaline ſulphures; but the decompoſition is attended with different phænomena, according to the differences of the nature of thoſe compounds. With the alkaline ſulphures it forms black ſulphure of mercury, which at the end of ſeveral years is found to have changed its black colour fot red. With ammoniacal ſulphure, it is very readily converted into black ſulphure of mercury, which in a few hours, or at moſt in a few days, takes a bright red colour. The yellow and the red oxide of mercury formed by fire or acids, exhibit ſooner or later the ſame phænomenon with ammoniacal ſulphure. It is produced alſo by pouring that liquor into ſolutions of mercury, and expoſing the black precipitate which reſults from the mixture to a new quantity of ammoniacal ſulphure.

I have diſcovered that running mercury ſhaken in water impregnated with hydrogenous gas, ſulphurated either naturally or artificially, decompoſes it very readily, and changes it into a black ſulphure.

We know not in what manner mercury acts upon arſenic. Cobalt does not combine with this metal. Biſmuth is eaſily diſſolved by mercury, and combines with it in any proportion. From this combination there reſults a bright friable matter, which is more or leſs ſolid, according to the quantity of the biſmuth. This amal-

gam

gam cryſtallizes into four-ſided priſms, which ſometimes unite into octohædrons; but it is moſt frequently cryſtallized into thin plates of no regular form. This cryſtallization is effected by melting the combination, and ſuffering it to cool ſlowly. When heated in a retort, it gives out, but very refractorily, the mercury which ſerves as its ſolvent.

Mercury does not unite with either nickel or antimony. It combines with zinc by fuſion. The amalgam which it forms with that ſemi-metal is ſolid: it is rendered fluid by trituration. When it is melted and ſuffered to cool ſlowly, it cryſtallizes into plates, which appear to be ſquare and rounded on the edges.

Mercury is much uſed in the arts, ſuch as gilding, ſilvering of glaſs, the conſtruction of meteorological inſtruments, metallurgy, &c. This ſemi-metal is uſed in medicine almoſt under every form.

1. Crude mercury was formerly uſed in the volvulus or iliac paſſion. It is ſtill boiled in water, and is thought to communicate the properties of a vermifuge. It is mixed with fats, and applied as an ointment in venereal complaints.

2. *Turbith mineral*, or yellow oxide of mercury by the ſulphuric acid, has been recommended in the ſame caſes, in doſes of a few grains. This medicine is emetic and purgative, and often acts too powerfully in both ways.

3. Mercurial water, or its nitric ſolution, is uſed by ſurgeons as a powerful eſcharotic. Red precipitate, or red oxide by the nitric acid, ſerves the ſame purpoſe. There is a citron-coloured ointment made up of hog's-

lard

lard and the nitrous ſolution of mercury, which is an excellent cure for the itch.

4. Corroſive mercurial muriate has been recommended by Sanches and Van Swieten in venereal caſes. A few grains of it are diſſolved in *aquavitæ*, and the ſolution is taken by ſpoonfuls, diluted in a large quantity of ſome cooling drink. The ſtate of the breaſt ſhould be attended to when this medicine is adminiſtered, and it ought to be given with great caution. Mild mercurial muriate is given in doſes of twelve or fifteen grains as a purgative, and in doſes of three or four grains as an alterative. Phagedenic water is uſed in ſurgery to corrode and deſtroy proud fleſh, &c.

5. Mercurial borate has been ſucceſsfully employed in venereal caſes by M. Chauſſier, the younger, of the Academy of Dijon.

6. *Cinnabar* has been undeſervedly conſidered as antiſpaſmodic and ſedative. It is one of the principles of Stahl's *pulvis temperans*, which, according to the pharmacopœia, is prepared by mixing exactly three drachms of ſulphate of potaſh and nitre with two ſcruples of artifical *cinnabar*. This medicine is adminiſtered by expoſing the ſick perſon to its vapour; and this is one way of treating people ill with the venereal diſeaſe by fumigation.

All the preparations of mercury which are given internally ſuit many other caſes beſides venereal complaints: Such are almoſt all cutaneous diſorders, a ſcrophulous habit, ſwellings of the lymphatics, &c. Yet we cannot avoid obſerving, that theſe medicines, and eſpecially all ſaline preparations of it, ought to be employed by none but ſkilful and cautious phyſicians; it

it is dangerous for the health, and even for the lives of mankind, that mercurial medicines ſhould be in the hands of ſuch a number of people who are deſtitute of the knowledge requiſite to adminiſter them; not only ſo as to be beneficial, but even ſo as not to do harm. I have oftener than once been witneſs of the unhappy effects produced by thoſe preparations, in conſequence of their having been adminiſtered by ignorant perſons, with that raſhneſs which uſually accompanies ignorance. We even think this an object of ſufficient importance to merit the attention of government.

CHAP.

CHAP. XVI.

Of Tin.

TIN, the *Jupiter* of the alchemiſts, is an imperfect metal of a white colour, brighter than lead, but darker than ſilver. It is very pliant, and when bent produces a crackling noiſe, called *the cry of tin.* We have already taken notice of the ſame phænomenon as belonging to zinc, though in a leſs eminent degree; a circumſtance which has induced Malouin to repreſent that ſemi-metal as nearly allied to tin.

This noiſe ſeems to be owing to the ſeparation or ſudden diviſion of the parts of the metal; and it ſeems to indicate a fracture; though tin, as we have already mentioned, makes ſcarce any reſiſtance to a force directed to bend it.

Tin is the lighteſt of all metals. It is ſo ſoft that it may be marked with the nail. In water, it loſes about a ſeventh

a ſeventh part of its weight. It has a very diſcernable ſmell; and when it is rubbed, that property becomes ſtill more eminent. It has a diſagreeable taſte, peculiar to itſelf; which is even ſo ſtrong, that ſome phyſicians aſcribe to this metal a pretty ſtrong power of action on the animal œconomy, and have recommended it for ſeveral diſeaſes. Being ſo exceſſively ſoft, it is ſcarcely ſonorous. Tin holds the ſecond place among metals, arranged according to their ductility; under the hammer it is reducible into plates thinner than leaves of paper, which are of great uſe in various arts. It is ſo tenaceous that a tin thread, one-tenth of an inch in diameter, will ſuſtain without breaking a weight of forty-nine pounds and an half. M. Mongez could not accompliſh the cryſtallation of tin. M. de la Chenaye, a gentleman who ſtudied under me, has effected it by melting the metal for ſeveral times ſucceſſively. By this means he has obtained a rhomboidal aſſemblage of priſms or needles joined longitudinally.

Moſt mineralogiſts ſtill doubt the exiſtence of native tin. Several authors, however, aſſert, that it is found in Saxony, in Bohemia, and in Malacca. It even appears to be a ſufficiently atteſted fact, that there is native tin in the tin mines of Cornwall: and M. Sage has deſcribed a ſpecimen which he received from Mr Woulfe, a London chemiſt. The fracture of that piece is grey and ſparkling; when beaten on the anvil, it forms brilliant and flexible plates of tin. Tin is more commonly met with in a black oxide, ponderous, opaque, and cryſtallized in octohædrons, or pyramids with four faces. The texture of this ore is ſparry and lamellated

lamellated. Bucquet thinks it to be a true carbonate of tin. M. Sage is of opinion that theſe cryſtals are mineralized by the muriatic acid. We may here recollect, that moſt of the white tin cryſtals in cabinets of natural hiſtory are native tunſtate of lime, which ought not to be confounded with oxide of tin, as the oxide does not become yellow when brought into contact with acids.

Thoſe matters which are denominated tin ores, are of a very deep red, violet, or black colour, and their ſpecific gravity is greater than that of any other mineral ſubſtance. Thoſe ores are ſometimes cryſtallized in irregular cubes; and they are then diſperſed in groupes in a gangue of quartz or fuſible ſpar. They are often in maſſes, not cryſtallized. Almoſt all naturaliſts agree in conſidering coloured tin ores as combinations of tin with arſenic, and aſcribe their uncommon ponderoſity to the want of ſulphur. Meſſrs Sage and Kirwan, however, think they contain no arſenic; and the former of theſe gentlemen affirms that they need not to be roaſted, unleſs they be mixed with arſenical pyrites; which is very common. Mr Kirwan ſays, black tin ore contains $\frac{80}{100}$ of tin and iron.

Bergman has found ſulphureous tin in nature among the minerals of Siberia. The ſpecimen of that ſulphureous ore which he examined, was externally of a golden colour, reſembling *aurum muſſivum*: within, it exhibited a maſs of radiated cryſtals, white, ſparkling, brittle, and changing its colour when expoſed to the air. He found it to contain a little copper.

We know of no tin ores any where in France. M. Baumé, however, ſuſpects that ſuch ores might be found

found in the neighbourhood of Alençon, and in ſome of the diſtricts of Brittany, becauſe there are rock cryſtals found there which appear to be coloured with this metal. The places where theſe ores abound, and are wrought in mines, are the counties of Cornwall and Devonſhire in England, Germany, Bohemia, Saxony, the iſland of Banca, and the peninſula of Malacca in the Eaſt Indies. Many naturaliſts conſider garnets as a kind of tin ore, on account no doubt of their colour. They differ from tin ores, however, in tranſparency and in gravity; for they are much lighter. Beſides, Meſſrs Buchet and Sage could find no tin in them.

Tin exiſts in nature but in a few different ſtates, which may be all reduced to the following varieties.

Varieties.

1. Native tin in leaves or plates.
2. White ſparry tin ore, in octohædral cryſtals.
3. Tin ore, of a yellowiſh white colour, often coloured and ſemi-tranſparent, like topazes.
4. Brown, reddiſh tin ore, in cubic cryſtals, more or leſs regular.
5. Tin ſtone, Swediſh *tinberg*. This is a ſtone or ſand, containing a mixture of oxide of tin; it is grey, blue, brown, or black.
6. Sulphureous tin ore, of a bright colour, reſembling zinc, or gilded over like *aurum muſſivum*.

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In aſſaying tin ore, it muſt firſt be broken into lumps, then coarſely pounded, waſhed, and roaſted in a covered earthen capſule, in order that as little tin as poſſible may be loſt, care being taken, however, to uncover it from time to time; for as Cramer has remarked, a good deal of the metal is loſt when it is roaſted in a veſſel conſtantly open. It muſt likewiſe be quickly roaſted, that the tin may not be too much oxidated. M. Baumé propoſes to obviate theſe inconveniencies by adding a portion of pitch, which reduces a part of the oxide formed in this operation. After the ore is roaſted, it is to be quickly melted in a crucible, with three parts of black flux and a little decrepitated marine ſalt. By comparing the three weights of the waſhed ore, the roaſted ore, and the metallic button, it may be eſtimated what quantity of extraneous matters the ore contains, and what quantity of tin it will yeild in the hundred weight. Cramer propoſes a more expeditious way of making this aſſay,—by which, too, leſs of the ore is likely to be loſt,—by uſing two large pieces of charcoal burnt from linden or hazel wood. In one of theſe there muſt be a cavity to contain the tin ore with the pitch, inſtead of a crucible; the other muſt be pierced with a ſmall hole through which the vapours may eſcape. The latter of theſe covers the former; and they muſt firſt be luted, and afterwards bound together with iron wire. They are then ſet on fire before the nozzle of a forge bellows, and kept up againſt it by other pieces of coal placed around them. After they have got enough of the fire to melt the tin, they are quenched with water, and the tin is found in a metallic button.

Bergman

Bergman propoſes to aſſay tin ores by diſſolving them in ſulphuric acid, mixing that with muriatic acid, and precipitating the mixture with fixed alkali. When the tin is pure, 131 grains of this precipitate are equal to 106 grains of tin. If it be mixed with copper and iron, theſe extraneous metals are ſeparated by the nitric and the muriatic acid.

The working of tin ores in the great way reſembles the foregoing proceſs. It is often neceſſary to make fires of wood in the mines, to calcine and ſoften the gangue, which is very hard. Theſe fires diſengage vapours that are very noxious. This proceſs is followed at the hills of Geyer. At other times thoſe ores are found in ſand, at no great depth beneath the ſurface of the earth, as at Eiberſtock. The ore is there pounded, and waſhed in boxes with ſmall partitions of cloth to retain the metallic particles. It is then roaſted in reverberating furnaces, with horizontal chimnies fitted to them, to collect the ſulphur and arſenic. It is then melted in a furnace with a ſleeve furnace, and poured into moulds which give it the form of blocks. In Germany and England tin ores are wrought nearly in the ſame way. In England, according to Geoffroy, the metal is always alloyed with lead and copper, and never exported pure. There comes too from England a ſtalactitical tin, which is called *tin in tears*, and is thought to be very pure; but Meſſrs Bayen and Charlard affirm, that it is ſometimes mixed with copper. The hardeſt tin of all is that which comes from Malacca and Banca. Malacca tin appears to have been run into moulds, which have given it the form of a truncated quadrangular pyramid, with a thin border round its baſe; this

is ſaid to be in hats or ſtandiſhes: Each piece weighs about a pound. The tin of Banca is in oblong ingots of about forty-five or fifty pounds. Both theſe kinds of tin are covered with a dirty grey ruſt more or leſs thick.

The tin which we get from Engand, and which being cheaper, is much more uſed than pure Indian tin, is in large blocks, each weighing about three hundred pounds. It is alloyed with copper, either artificially, as Geoffroy tells us, or naturally, according to the Baron de Dietrich. That it may be more eaſily retailed, it is afterwards melted into ſmall ingots or ſticks, about nine or ten inches in circumference, and a foot and an half long *.

When tin is expoſed to fire in cloſe veſſels, it melts very quickly. It is the moſt fuſible of all metals. If the fire be not increaſed it remains fixed; but its fixity appears to be only relative; for when expoſed to a conſiderable heat it is volatilized, as we are juſt about to relate. If heated in contact with air, there appears on its ſurface as ſoon as it is melted a dirty grey pellicle, which contracts into a ſhrivelled form. On taking it off, we behold the tin beneath, with its proper metallic luſtre, and not adhering to the pellicle: but it loſes this appearance, and a new pellicle is formed. The whole quantity of tin in fuſion may be in this manner carried off in pellicles, which are nothing but the oxide of the metal, or a combination of the metal with

* It is not true that tin is never exported pure from England: But however pure it may be exported, foreign tin-founders uſually take care to alloy it, and aſcribe the alloy to the Engliſh. Neumann tells, that the Dutch keep Engliſh ſtamps for the purpoſe.

with the oxigene of the atmoſphere. Tin, when reduced to oxide, becomes one-tenth heavier. When this metal is made red hot, Geoffroy has obſerved, that its oxide is gradually ſublimated by a very lively whitiſh flame, which he compares to the flame of zinc. This is actually an inflammation or rapid combuſtion of the metal: and the volatilized tin ariſes at the ſame time in a light ſmoke, which condenſes on cold bodies to a whitiſh oxide of tin in needles. The grey oxide of tin becomes white on being again expoſed to the action of fire; it then unites with a new portion of oxigene, and is more completely calcined. In this ſtate it is called *tin-putty*. When expoſed to a very intenſe heat, like that of a porcelain furnace, it melts into a glaſs. Meſſrs Macquer and Baumé have obſerved, on treating tin in this way in a crucible, that a part of it was changed into a white, needled oxide; while another part under the former was hard, reddiſh, and half melted; a third was converted into ruby or hyacinth coloured glaſs; and, laſtly, there remained in the bottom of the crucible a portion of the tin in its metallic ſtate. Notwithſtanding of this, oxide of tin is ſtill conſidered as infuſible; and it is at leaſt the moſt refractory of all oxides. This oxide may be decompoſed with the help of combuſtible animal or vegetable matters; which by detaching the oxigene enable the metal to reſume all its properties. It appears, however, that *tin putty*, when thoroughly calcined, retains, with no inconſiderable force, the oxigene with which it is united; for to reduce it is very difficult, and a great quantity of combuſtible matters muſt be employed for the purpoſe. This has led M. Baumé and ſeveral o-

ther chemiſts to think, that when tin ores are too much roaſted, a part is ſo changed as to be no longer ſuſceptible of reduction.

Tin does not ſuffer much alteration from air; when very pure, it is ſcarce liable even to loſe its luſtre. That which commonly paſſes in commerce is at length covered over with a grey duſt; but this duſt, according to Macquer, never penetrates deeper than the ſurface, as the ruſt of iron does.

Water does not diſſolve or calcine tin; yet a piece of tin expoſed to the action of water is at length tarniſhed, and ſeemingly calcined on its ſurface.

Earthy matters never contract any union with this metal; its oxide being ſo very infuſible, never forms either tranſparent or coloured glaſs with vitrifiable ſubſtances. But as it is ſo very white, it is capable of interpoſing itſelf among the particles of glaſs, ſo as to render it very opaque, and of a dead white colour. This ſort of vitreous frit is called *enamel*. The infuſibility of tin putty enables it to deſtroy the tranſparency of any kind of glaſs, and convert it into a coloured enamel.

We know not in what manner lime, magneſia, or alkalis act upon tin: but there can be no doubt that alkalis, with the help of water, may effect ſome alteration on this metal; for they in a very ſhort time cauſe it to aſſume the colours of the rainbow.

According to Kunckel, the concentrated ſulphuric acid diſſolves half its weight of tin; heat favours this ſolution. A very pungent ſulphureous gas is diſengaged from the matters, without any very diſcernible emotion or effervеſcence. In this operation, the tin

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ſeizes the oxigene of the ſulphuric acid; it is quickly oxidated, and the acid retains ſo much of it as to afford a precipitate by water. The ſulphuric acid, diluted in a little water, acts in the ſame manner on tin: but this ſolution is more permanent, and does not afford ſo copious a precipitate by water as the former. When the acid is very weak, it does not diſſolve tin at all. In this combination the tin attracts ſo much oxigene from the ſulphuric acid as to form ſulphur very quickly. The ſulphur communicates a brown colour to the ſolution when it is hot, and when it is cold ſubſides as a precipitate. Meſſrs Macquer and Baumé are convinced of the preſence of ſulphur in this combination. On continuing to heat the ſolution, the tin is precipitated in a white oxide. The ſame phænomenon will at length take place, even without the help of heat. The ſulphuric ſolution of tin is very cauſtic. M. Monnet obtained from it by cooling, cryſtals reſembling thoſe of calcareous ſulphate, or in fine needles intermixed and intwined with one another. The oxide of tin precipitated from this ſolution by reſt and heat, is ſoluble in the ſulphuric acid. If the ſulphuric ſolution of tin be evaporated to dryneſs, the oxide which it then affords is grey, ſcarce reducible, and not ſoluble in that acid. The alkalis precipitate tin diſſolved in the ſulphuric acid in a very white oxide.

Tin decompoſes the nitric acid, even cold, with amazing rapidity. This is one of the moſt aſtoniſhingly rapid ſolutions in all chemiſtry. Tin appears to have a very ſtrong tendency to combine with the oxigene of the nitric acid; and as the azotic principle does not adhere to the oxigenous with near the ſame obſtinacy as

the ſulphur does in the ſulphuric acid, it is not at all ſurpriſing that the nitric acid ſhould be decompoſed by tin in a much more rapid and lively manner than the ſulphuric acid. M. de Morveau has obſerved, that in a ſolution of tin by the nitric acid, there was no gas diſengaged, but there was a portion of ammoniac formed. It appears then, that not only the nitric acid, but the water, is decompoſed by tin; for the ammoniac formed in this operation can only be formed by the union of the hydrogene of the water with the azote of the acid of nitre.

The tin is reduced into a white oxide, which Macquer ineffectually attempted to reduce to metal: this metal therefore appears to be ſuperſaturated with oxigene. The nitric acid retains only a little of it in ſolution; and when it is evaporated with a view to obtain nitrate of tin in cryſtals, the tin which was diſſolved in the acid is very ſoon precipitated, leaving the acid almoſt pure. Bucquet, however, aſſerts, that a very deliqueſcent nitre of tin may be obtained from this ſolution; but he has not determined its form. He aſſerts likewiſe, that on waſhing calx of tin formed by the decompoſition of the nitric acid, the water diſſolves a little nitrate of tin, which may be obtained from it by evaporation. The nitric acid retains a little more tin diſſolved in it when it is diluted in a large proportion of water; but it precipitates the oxide which it has thus obtained either by heat or by reſt. Meſſrs Bayen and Charlard, in their valuable experiments on tin, have diſcovered, that when the nitric acid is impregnated with as much tin as it can reduce to oxide, and made ſo thick with it as to be unfit for acting on any

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other metal; the mass, if copiously washed with distilled water, and evaporated to dryness, gives a *stanno-nitrous* salt, which detonizes by itself in a hot roasting pot, and burns with a white thick flame like that of phosphorus. Oxide of tin sufficiently lixiviated, affords by exsiccation a semi-transparent mass resembling scales. The *stanno-nitrous* salt, when distilled in a retort, swells, boils up in bubbles, and on a sudden fills the receiver with a white thick vapour of a nitrous smell.

The fuming muriatic acid acts with considerable strength on tin: it dissolves the metal with the help of heat, or even cold; but instantly loses its colour and the property of fuming. The faint effervescence which takes place on this occasion, disengages from the mixture an inflammable fœtid gas, which, however, has no resemblance to the fœtor of arsenic, notwithstanding what some chemists have pretended to the contrary. Water is therefore decomposed by tin, with the help of the muriatic acid. That acid dissolves in this process more than half its own weight of tin. The solution is yellowish, has a very fœtid smell, and affords not, like the preceding solutions of tin with acid, a precipitate of oxide of tin. When this solution is evaporated, it affords very regular brilliant needles, which attract a little moisture from the air. M. Monnet says that those needles, after falling into a deliquium, crystallize, and remain dry in the air. M. Baumé, who has prepared muriate of tin in the great way, with an hundred and fifty pounds of acid to twenty-five pounds of tin, for the manufacture of printed cloths, gives an accurate account of several of its properties. Of twelve pounds

of tin diſſolved in forty-eight pounds of muriatic acid, there remained two ounces and ſix drachms in a grey powder; which did not diſſolve in a pound of the acid, though digeſted in it for a number of days. Margraaf thinks it to be arſenic. M. Baumé has not examined it. He compares the ſmell of that ſolution concentrated to that of the black earths of old privies; and obſerves, that when it falls on the fingers, it is impoſſible to waſh or wipe away the metallic ſmell of tin which it communicates to them, but which goes off of itſelf in the courſe of four and-twenty hours. He obſerves, that the cryſtals of muriate of tin vary according to the ſtate of the acid: Sometimes they are little white needles. From the ſame ſolution he obtained both white and roſe-coloured needles. The roſe-coloured, when purified by ſolution and evaporation, afforded, by cooling, large cryſtals nearly like thoſe of ſulphate of ſoda. At other times, employing the common muriatic acid, he obtained the ſalt in ſmall pearl-white ſcales, like thoſe of the boracid acid. He does not mention the action of fire on this ſalt. M. Monnet, who diſtilled the muriatic ſolution of tin, affirms, that he obtained from it a very fuſible unctuous matter,—in ſhort, a true butter of tin, and fuming liquor like that of Libavius, which we ſhall hereafter mention. This fact agrees with what Macquer has obſerved concerning a ſolution of tin in the muriatic acid, which was almoſt entirely cryſtallized during winter, but became fluid again in ſummer; a property which is found to belong to ſublimated muriate of tin. That illuſtrious chemiſt has obſerved, that after a number of years there was a white ſediment formed in this ſolution.

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The combination of the muriatic acid with oxide of tin affords a much more copious precipitate than any of the other ſolutions of this metallic calx, by alkalis or lime. The alkalis again diſſolve a part of the precipitated oxide, and aſſume a brown yellow colour. By diſſolving large blocks of Engliſh tin, and in general all impure tin in this acid, Meſſrs Bayen and Charlard diſcovered at length that Engliſh tin contains ſome particles of arſenic. When tin contains arſenic, in proportion as the acid acts on the tin the metal aſſumes a black colour; and when it is totally diſſolved, there remains a blackiſh powder; which is pure arſenic, or arſenic combined with a ſmall portion of copper. This acid may therefore be employed to aſcertain the preſence of arſenic in tin, and determine its quantity.

The oxigenated muriatic acid diſſolves tin very readily, and without diſcernible effervescence; for the metal quickly abſorbs the exceſs of oxigene in the acid, without decompoſing the water in order to unite with the oxigene which *it* contains. This ſolution poſſeſſes of conſequence all the properties of the foregoing ſolution.

The mixed nitro-muriatic acid, conſiſting of two parts of nitric acid and one of the muriatic, combines with tin with effervescence. It produces a ſtrong heat, which ſhould be diminiſhed by immerſing the mixture in cold water. To compoſe a permanent ſolution of tin in this mixed acid, care muſt be taken to put the metal only by degrees into the acid, and to wait till the firſt portion be entirely diſſolved before putting in a ſecond. If a large quantity of the metal were put all at once into the acid, moſt of it would be oxidated. *A-*

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qua-regia is capable of diſſolving and holding in ſolution half its weight of tin. This ſolution is of a reddiſh brown colour; but its colour is very faint: it often forms in a few moments a tremulous jelly, of the appearance of roſin. This ſubſtance becomes in a few days more ſolid; at the end of which time it may be cut like a firm animal jelly. Some portions of it exhibit the ſemi-tranſparency and whiteneſs of the opal. It exhales a poignant ſmell of muriatic acid; but this ſmell is not fœtid like that of the muriatic ſolution of tin. I have preſerved ſome of it for ſeveral years in a bottle but indifferently ſtopped, and it loſt nothing of its tranſparency or ſolidity. In order that tin diſſolved in *aqua-regia* may form a jelly, the ſolution muſt contain a good deal of the metallic oxide. Sometimes, on adding it to half its weight of water, it becomes concrete, though not ſo before. But this jelly, formed by the help of water, is of an equal colour; becauſe, as has been remarked by Macquer, this ſolution being ſuſceptible of decompoſition by water, a portion of oxide is precipitated and deſtroys the tranſparency of the jelly. That ſkilful chemiſt has farther obſerved, that when the ſolution of tin in aqua-regia is heated, a lively effervescence takes place, owing to the re-action of the mixed acid on the metal, on which it ſtill retains ſome power of acting. The ſolution then loſes its colour, and becomes fixed by cooling. The jelly new formed is beatifully tranſparent. By reſt, a liquid regaline ſolution of tin ſometimes depoſites ſmall needle cryſtals. Neither theſe, nor the gas diſengaged during the action of the nitro-muriatic acid on tin, have yet been examined. Meſſrs Bayen and Charlard have found that this

this ſolvent might likewiſe be uſed to aſcertain the preſence of arſenic in tin; but that as it acts with conſiderable force on the ſemi-metal, it would not determine the quantity ſo preciſely as the muriatic acid itſelf is capable of doing.

We know not in what manner the other acids act upon tin. All ſulphuric neutral ſalts, eſpecially ſulphate of potaſh or ſoda, are liable to be decompoſed by tin. By heating in a crucible equal parts of ſulphate of potaſh and tin, I obtained a greeniſh melted maſs, which had no metallic properties, but was a true ſtannic ſulphure. Tin detaches the oxigene from the ſulphuric acid. The ſulphure ſeparated by this decompoſition combines with the potaſh; and that ſulphure diſſolves a portion of the oxide of tin. This is the third metallic ſubſtance which we have found to poſſeſs the property of decompoſing alkaline ſulphates. We will preſently ſee that Glauber had taken notice of this fact in regard to ammoniacal ſulphate.

This metal makes nitre detonize rapidly. It is melted and heated in a crucible till it aſſume a dark red colour, and the nitre then thrown on it in a powder. A white ſparkling flame accompanies the detonation. When more nitre is added, the detonation no longer takes place, the tin being entirely reduced to oxide. The white powder which remains contains alkali rendered cauſtic by the oxide of tin, and even combined with a certain quantity of that oxide. On forming it into a lixivium, the tin may be precipitated by an acid. If the grey oxide of tin melt with nitre, as Geoffroy has obſerved, the reaſon of this muſt be its ſtill containing a portion of tin not reduced to oxide; for

for when we take a perfect oxide of this metal, that for inſtance which has long been expoſed to heat, and is very white, or rather that which owes its formation to acids; neither of theſe exhibits any ſuch phænomenon.

Tin decompoſes ammoniacal muriate very readily: a quantity of ammoniac, ſtrongly cauſtic, and in a gazeous ſtate, is diſengaged. Bucquet, who made a ſeries of experiments on the decompoſition of ammoniacal ſalts by metallic matters and their oxides, obſerves, that a good deal of inflammable gas is diſengaged by the reaction of tin on ammoniacal muriate. According to the experiments of that ſkilful chemiſt, metals decompoſe this ſalt in conſequence of the muriatic acid acting upon them. As we have ſeen that the muriatic acid has a very conſiderable affinity with tin, we may conclude Bucquet's theory to be ſatisfactory and conſiſtent with facts. Glauber gave out, that his ſecret ammoniacal ſalt, or ammoniacal ſulphate, was decompoſed by tin; but according to Pott, who repeated Glauber's experiment, the decompoſition is not complete, doubtleſs becauſe the ſulphuric has not ſo ſtrong a tendency as the muriatic acid to combine with tin. Bucquet likewiſe obſerves, that as tin is very fuſible, it gathers into a button at the bottom of the retort; and that the ammoniacal muriate of conſequence is not ſo completely decompoſed by the metal as it might otherwiſe be. This is the reaſon why tin does not decompoſe this ſalt ſo completely as the leſs fuſible metals. The reſidue of this decompoſition is ſolid muriate of tin, decompoſable by water, and reſembling that formed by corroſive muriate of mercury with this metal; of which we will hereafter ſpeak.

Tin

Tin may be eaſily combined with ſulphur by caſting one or two parts of this combuſtible matter in powder upon five or ſix parts of tin melted in an iron ladle: this mixture, being ſtirred with an iron ſpatula, becomes black and kindles. When melted in a crucible, it forms a brittle maſs in flat bundled needles. This compoſition is much more difficult to melt than tin; and in the ſame manner all ſoft fuſible metals are leſs eaſily melted when mixed with ſulphur than when pure. But it is worthy of our notice, that though tin may be alloyed with ſulphur, yet this mixture is never found in nature. With zinc the caſe is directly oppoſite; for though in nature it be often found combined with ſulphur, yet in the laboratory we find it exceedingly difficult to effect ſuch an union. Nature often differs greatly in her operations from art: but if ſhe ſometimes effect combinations which art cannot imitate, art alſo forms combinations of which nature diſplays no pattern.

Arſenic ſcarce unites with tin by fuſion; being moſtly diſſipated by volatilization on ſuch an occaſion. Arſeniate of potaſh combines better with this metal; and M. Baumé has obſerved, that in this combination a part of the acid of arſenic forſakes the alkali, in order to unite with the tin, to which it yields a part of its oxigene, and the reſult is a brittle and very brilliant button with facets like antimony, Margraf's experiments on the union of tin with oxide of arſenic by diſtillation, ſhow, that a part of that oxide is reduced to arſenic, while, again, ſo much of the tin is oxidated: that when tin is once united with arſenic, it cannot be again ſeparated from it even by the moſt violent action of fire; and that tin probably retains always a certain portion of arſenic, which

which may render it dangerous in kitchen uſes. By diſtilling oxide of tin impregnated with arſenic, Margraf obtained a liquor of a phoſphoric ſmell. Meſſrs Bayen and Charlard have ſince examined the combination of arſenic with tin. They have obſerved, that the oxide of arſenic, ſimply called *white arſenic*, cannot combine with tin unleſs it be reduced to the metallic ſtate; and that the combination may be much better effected by a direct combination of *regulus* of arſenic with tin. If you put into a retort three ounces ſix drachms of tin, with two drachms of *regulus* of arſenic in coarſe powder, and after fitting a receiver to the retort, make it red hot, nearly two grains of arſenic riſe into the neck of the retort, and a metallic button, four ounces in weight, is found in its bottom. This mixture, which contains one ſixteenth of arſenic, is cryſtallized in large facets like biſmuth. It is more brittle than zinc, and more difficult to melt than tin. It becomes ſoft at firſt; and if it be touched while in this ſtate with an iron rod, a ſound is heard, produced by the friction of the plates againſt one another. It melts into a clammy paſte; and the arſenic goes then gradually off in a ſmoke.

Cobalt unites with tin by fuſion, forming a mixture with fine grains cloſely united, and of a light violet colour.

Tin and biſmuth form, according to Gellert, a brittle mixture with cubic facets. Workers in tin ſometimes mix it with biſmuth to render it white and hard. As it renders it much harder, and is dearer than zinc, which produces the ſame effects on tin, the workmen employ it only in the proportion of a pound, or a pound and an half of biſmuth

to

to the hundred weight of tin: and we have nothing from its effect on the animal œconomy; effects which the ſtrong analogy between lead and biſmuth in all their properties might move us to fear, as likely to be no leſs fatal than thoſe of that metal. Biſmuth may be ſeparated from tin with the help of the muriatic acid; which diſſolves the tin, leaving the biſmuth ſeparate in the form of a white powder, provided the weak muriatic acid be employed. The nitro-muriatic acid, when diluted in water, produces the ſame effects.

Antimony combined with tin, forms, according to Gellert, a very brittle white metal; the ſpecific gravity of which is leſs than that of the two metallic ſubſtances taken ſeparately.

Zinc is eaſily combined with tin; and the reſult is a hard metal with ſmall grains cloſely united; and the more ductile in proportion as the quantity of the tin is greater.

Cronſtedt aſſerts, that nickel combined with tin forms a white brilliant maſs; which, when calcined under a muffle, aſcends in the form of a vegetating ſubſtance.

Mercury diſſolves tin in any proportion with the greateſt facility. This combination is effected by pouring hot mercury into melted tin. The ſolidity of the amalgam thus produced varies with the proportions of the two metallic ſubſtances. Formerly there was an amalgam compoſed of four parts of tin, and one of mercury, and run into balls, which, when they cooled, became ſolid. Thoſe balls were ſuſpended in water to purify it. The water was at the ſame time boiled; and the precipitation of the extraneous matter which alter-

ed

ed it was entirely owing to ebullition. This amalgam of tin is ſuſceptible of cryſtallization. It forms little ſquare cryſtals, as M. Daubenton has obſerved of the amalgam of tin, which he uſed for ſtopping the mouths of veſſels containing preparations in the King's garden. Sage ſays, theſe cryſtals are grey and ſparkling, in foliated plates, thinner at the edges than in the middle, and the interſtices among them polygon figures.

Tin having a greater affinity than mercury with oxigene, decompoſes corroſive mercurial muriate. To effect this decompoſition, the tin is firſt divided by means of a little mercury: equal parts of this amalgam and corroſive mercurial muriate are then triturated together; and the mixture is diſtilled in a glaſs retort by a very moderate heat. There paſſes firſt into the receiver a colourleſs liquor; ſoon after, this is followed by thick white vapour, which is forced up with a ſort of exploſion, and covers the ſides of the receiver with a very thin layer. This vapour is condenſed into a thick, white, and very copious ſmoke, known by the name of *Libavius's fuming liquor*. It is a combination of the muriatic acid with tin, in which the acid appears to become ſuperſaturated with oxigene. This liquor, when incloſed in a phial, does not diffuſe any viſible vapour. There is, however, a certain quantity diſengaged from it, which depoſites oxide of tin in needle cryſtals on the upper part of the phial; ſo that in a few months the lower end of the neck is entirely cloſed up. A little of this oxide is likewiſe precipitated to the bottom of the liquor in unequal leaves. Its ſmell is very pungent, and makes a perſon ſneeze. Its vapours are not viſible except when in contact with the air. They

ſeem

ſeem to conſiſt of a gas of a peculiar nature, which is decompoſable by air; and on coming into contact with air yields a precipitate of oxide of tin, in the ſame manner as the fluoric acid gas affords, on coming into contact with water, a precipitate of ſiliceous earth, and as ſulphurated hydrogenous gas depoſites ſulphur when expoſed to the contact of air. Can this be a combination of oxigenated muriatic acid gas with oxide of tin?

Water does not produce any diſcernible precipitate in *Libavius's fuming liquor:* but it appears to operate upon it a decompoſition which has not yet been properly examined. When a quantity of this liquor, newly prepared, is poured into diſtilled water, it produces a kind of hiſſing like that which the ſulphuric acid, highly concentrated, produces when mixed with water. It appears to ſeparate into a great many ſmall particles, which are tranſparent and irregular, and ſeem to have no adheſion to the water. On a near obſervation of what paſſes when this mixture is made, bubbles are perceived riſing from theſe particles to the ſurface of the water, where they are reduced to vapour, which is rendered white by the contact of air. When the water is ſtirred, thoſe particles are quickly diſſolved; and the ſolution ceaſes to exhale vapour. Macquer affirms, that when this fuming liquor is diluted in a large quantity of water, it precipitates an oxide in light white flakes.

The gas of the fuming liquor is ſcarce elaſtic. It never puſhes out the ſtopper of the phial in which it is confined; as the nitric and the muriatic acids, ammoniac, and æther, &c. do.

M. Adet, who has read to the Academy a memoir on the *fuming liquor of Libavius*, has obſerved, 1. That the effervescence which takes place whenever it is mixed with water, depends on the diſengagement of an elaſtic fluid poſſeſſing all the properties of azotic gas: 2. That the fuming liquor, combined with water in the proportion of 7 to 22, forms a ſolid body which is melted by heat and congealed by cold, and appears to be ſubject to the ſame laws as oxigenated muriate of tin or butter of tin. From his ſeveral experiments he concludes the fuming liquor to be nothing but a compound of muriatic acid in the æriform ſtate, with oxide of tin having an exceſs of oxigene. This ſalt, he thinks, bears the ſame relation to common muriate of tin, which oxigenated muriate of mercury bears to common muriate of mercury, or *mercurius dulcis*.

The reſidue which remains after the diſtillation of the *fuming liquor of Libavius* exhibits as many intereſting phænomena as the liquor itſelf. The upper part and the neck of the retort are coated with a thin white or grey cruſt; which, according to the experiments of Rouelle the younger, contains a little of the *fuming liquor*, concrete muriate of tin, or corneous tin, mild mercurial muriate, and running mercury. The bottom of the veſſel diſplays an amalgam of mercury and tin, above which there is a little *corneous tin* of a grey white colour, ſolid and compact, and ſuſceptible of volatilization by a ſtronger heat. If this ſubſtance be put into a retort it melts, and divides into two ſtrata; the inferior ſtratum black, and the ſuperior white, and like the former, *corneous tin*. Rouelle appears to ſuſpect, that theſe two ſubſtances, thus different from each other,

and

and refuſing to mix, are owing to an alloy contained in the tin. According to that ingenious chemiſt, the more this metal is alloyed, the leſs *fuming liquor* does it afford. Solid muriate of tin attracts the moiſture of the atmoſphere, and is very readily diſſolved in water. M. Baumé has advanced a theory concerning the combination of tin with the muriatic acid, which is nearly the ſame with what Scheele and Bergman have advanced concerning what they call *dephlogiſticated marine acid*. He thinks that in this operation the acid loſes its *phlogiſton*, as thoſe chemiſts thought it did when diſtilled in oxide of manganeſe. He imagines that this acid might be obtained perfectly pure by a diſtillation of the *fuming liquor of Libavius*; from which it appears, that he conſiders the common muriatic acid as ſuperſaturated with *phlogiſton*. M Baumé was therefore prior to Scheele in the diſcovery of the two ſtates of the muriatic acid; but he has not deſcribed the ſingular properties which that acid poſſeſſes when oxigenated, as has been done by the celebrated Swediſh chemiſt.

The uſes of tin are very many. It is employed in a great number of the arts. It is uſed for lining a great many veſſels, or organ pipes, for decorations, &c. An amalgam of tin is employed for ſilvering glaſſes. Copperſmiths tin copper by running a mixture of tin and lead upon it: A mixture of tin with copper is uſed for bells and ſtatues of bronze. Tin workers mix it with biſmuth, antimony, lead, and copper for utenſils of all kinds; which are very liable to alteration by the action of air. Tin putty is uſed in poliſhing hard bodies. It is melted with oxide of lead and ſand for enamel, as well as for glazing earthen ware, &c. Cryſtallized mu-

riate of tin is uſed in printing cloth; a ſolution of this ſalt in *aqua regia*, or the nitro-muriatic acid, improves the dye of cochineal, gum lac, &c. ſo as to convert it to a lively fire colour. Dyers uſe this ſolution, calling it *a compoſition* for dyeing ſcarlet. When mixed on a bath with the above mentioned dyeing ſtuffs, it produces a precipitate which carries off the colouring particles, and fixes them on the cloth. We ôwe this obſervation to Macquer, whoſe labours have been very beneficial to the art of dyeing.

Some chemiſts have conſidered tin as very dangerous when uſed for kitchen utenſils. Navier, in his work on counter poiſons, &c. relates, that a number of perſons have been poiſoned by *rogouts*, in which tin-ſpoons had been ſuffered to ſtand for a while, and by ſugar, kept in tin canniſters. Theſe unhappy effects are uſually aſcribed to the arſenic, which Geoffroy in 1738 aſſerted that he had found to exiſt in tin, and which Margraaf thought he found in the pureſt tins, and in no inconſiderable quantity.

But the fears thus excited have been diſpelled by the experiments of Meſſrs Bayen and Charlard, of which we have already had occaſion to take notice in the hiſtory of this metal. Thoſe chemiſts have proved, by the moſt deciſive experiments, 1. That the arſenic obtained by Margraaf from the tin of Morlaix, amounting to nearly ſix and thirty grains to an half ounce of tin, would have been much more than ſufficient to deſtroy the known ſoftneſs and flexibility of the metal, and render it as brittle as zinc. 2. That the tins of Banca and Malacca contain not a particle of that dangerous ſemi-metal. 3. That large blocks of Engliſh tin, when

expoſed

expoſed to the action of the muriatic acid, afford a ſmall quantity of a blackiſh powder, which is generally mixed with copper and arſenic; the arſenic, however, never amounting to more than three-fourths of a grain to the ounce of tin, and being often under that proportion. 4. That this ſmall proportion of arſenic is rendered ſtill leſs by the tin workers, who uſually mix Engliſh tin with the purer tins of Malacca or Banca. 5. That arſenic by combination with tin loſes a part of its properties and of its corroſive powers. 6. Laſtly, That the very ſmall quantity of alloyed tin which enters into the aliments prepared in tin-veſſels, cannot poſſibly have any influence on the animal œconomy; for, from the moſt accurate calculation of the loſs ſuffered by a tin-plate in two years wear, it was found to have loſt not more than three grains a month; and of conſequence $\frac{1}{8760}$ of a grain of arſenic a day, ſuppoſing the tin work of Paris to contain as much of that poiſonous ſemi-metal as the tin-plate of London manufacture, on which M. Bayen made this obſervation.

We may obſerve, that if the chemiſts of Paris do not quite agree with Margraaf, the difference may be occaſioned by the difference between the Saxon tin, on which his experiments were made, and the Indian and Engliſh tins which they have examined.

Farther, many phyſicians who had ſtudied the medical powers of metallic matters had before pronounced tin perfectly harmleſs, and had even recommended the giving it in filings for diſorders affecting the liver, or the matrix, and for worms. Schulz, in his diſſertation on the uſe of metal veſſels in preparing aliments and medicines, thinks tin, when very pure, to be very ſafe. La

Poterie uſes oxide of tin in preparing a medicine which he calls *anti-hectic*, and which is nothing but a lixivium of oxide of antimony and oxide of tin formed by the detonation of nitre.

Tin has been recommended as a vermifuge. At Edinburgh large dozes of it have been adminiſtered without ſucceſs. Some country people are in uſe to leave ſweet wine ſtanding for four and twenty hours in a tin veſſel, and to give that liquor by glaſſes to their children for the worms. Navier ſaw a girl of the age of fifteen or ſixteen diſcharge by ſtool thirty large worms in a few hours after drinking a preparation of this kind. This medicine acts, therefore, as a violent purgative.

CHAP.

CHAP. XVII.

Of Lead.

LEAD is an imperfect metal of a dark white colour, inclining ſomewhat to blue. The alchemiſts gave it the name of *Saturn*, becauſe, as we will afterwards ſee, it abſorbs and devours, ſo to ſpeak, all other imperfect metals in its ſcorification. It is the leaſt ductile, the leaſt ſonorous, and the leaſt elaſtic of all metals. It may be hammered into thin plates: it is rendered very little harder by this operation. There is no metallic matter leſs tenacious than lead, a leaden thread $\frac{1}{10}$ of an inch in diameter cannot ſuſtain more than $29\frac{1}{2}$ pounds weight without breaking. In gravity it is the third metallic ſubſtance. A cubic foot of lead weighs 828 pounds: in water it loſes between $\frac{1}{11}$ and $\frac{1}{12}$ part of its weight: it is ſo very ſoft that it may be eaſily cut with

a knife. It has a very diſcernible peculiar ſmell, which becomes ſtill more diſcernible when it is rubbed: its taſte is ſcarce ſenſible to the palate, but irritates the nerves of the ſtomach and the inteſtines, ſo as to produce, firſt pains and convulſions, and at length ſtupor and palſy. It may be cauſed to aſſume a regular form. The Abbé Mongez obtained it in quadrangular pyramids lying on their ſides in ſuch a form that one of the four ſides was always much larger than the other three. Each pyramid conſiſts of ſtrata, or zones of other ſmaller pyramids, or rather octohædrons.

Lead is ſcarce ever found pure in the earth. Wallerius and Linnæus admit its exiſtence in that ſtate; which is denied, however, by Meſſrs Cronſtedt, Juſti, Monnet, &c. It is moſt commonly in an earthy, ſaline ſtate, or mixed with ſulphur, ſo as to form what is called *Galena*. Lead mines are generally at a great depth under ground, and are ſituated either in hills or in plains. Naturaliſts have diſtinguiſhed a great many ſpecies of lead ore. The following are thoſe moſt worthy of notice.

1. Native oxide of lead. This muſt not be confounded with *ſparry lead* which contains carbonic acid. This oxide does not effervеſce with the nitric acid. It is uſually in white or grey ponderous ſolid maſſes, perhaps mixed with clay, ſand, and chalk. The colour of the clay, according as it is more or leſs ferruginous, gains it the name of native *maſſicot*, or *minium*, or yellow and red oxide. Native ceruſe of lead is often met with on the ſurface of galenas.

2. Carbonate

2. Carbonate of lead, or oxide of lead combined with the carbonic acid. This ore varies greatly in colour: it is either white, black, brown, yellow, or green, according to the ſtate of the iron by which it is altered. It bears the general name of *ſparry lead*, its contexture and cryſtallization being the ſame with thoſe of certain ſpars. It effervesces with the nitric acid, which diſengages the carbonic acid it contains. This ſpecies is diſtinguiſhed into the following varieties.

Varieties.

A. *White ſparry lead.* This is carbonate of lead ſlowly depoſited in cryſtals by water. This lead is ſometimes ſemi-tranſparent like ſpar. Its cryſtals are uſually truncated hexahædral priſms, or ſtriated cylindric columns, which appear to conſiſt of a great number of filaments, or very ſlender ſmall needles. Some ſpecimens of this kind of lead are of a ſparkling white colour like *ſilky gypſum*. There are others of a yellowiſh white colour. There are generally ſome of theſe priſms fiſtulous. White ſparry lead is very plenteous in Low Brittany in the mines of Huelgoet and Poullaouen. M. Sage gave out, that white lead was mineralized by the muriatic acid. M. Laborié has affirmed it to be only a pure oxide of lead combined with fixed air, or carbonic acid, and mineralized by water. The Academy of Sciences at Paris having cauſed the experiments of both theſe chemiſts to be repeated, have adopted the opinion of M. Laborié; and Macquer has

Varieties.

has given it in his dictionary under the article *lead ores*. Sparry lead is always found in the ſame places with galena; and appears to be nothing but galena that has loſt its ſulphur, and of which the lead has been oxidated; for it is not uncommon to find galena beginning to paſs into the ſtate of white lead; as has been very well obſerved by M. Romé de Lille.

B. Some naturaliſts admit the exiſtence of black lead; that is, white lead altered by a ſulphureous vapour, and reduced to the metallic ſtate: it may be conſidered as poſſeſſing a kind of middle nature between white lead and galena. It is cryſtallized in irregular maſſes.

C. Green ſparry lead. This mineral is more or leſs of a tranſparent green, moſt frequently yellowiſh, and always mixed with ochre and earthy iron. Sometimes it has no regular form, but reſembles a kind of moſs. Of this kind are moſt of the ſpecimens from Hoffsgrund, near Friburgh, in Briſgaw. Green lead is commonly cryſtallized in hexahædral priſms, either truncated, or terminating in hexahædral pyramids entire, or truncated near the baſe. A good deal of it is found at Sainte-Marie-aux-Mines, and at Tſchoppau in Saxony. It has been proved that lead owes its green colour to a mixture of iron, as iron is always found in the ores of this metal.

D. Reddiſh ſparry lead of the colour of peach flowers. M. Mongez has found this variety cryſtallized

Varieties.

cryſtallized like white ſparry lead in the mines of Huelgoet.

E. Yellow ſparry lead. This variety, which is cryſtallized in tranſparent hexahædral plates, has been known only for theſe few years: the plates are from half a line to four or five lines in diameter: they reſemble glaſs of lead.

3. M. Monnet has diſcovered among lead ores ſome of the metal combined with the ſulphuric acid. It is commonly in a white maſs, ſoluble in eighteen parts of water: it is ſometimes blackiſh and cryſtallized in very long ſtriæ, or friable ſtalactites. This laſt variety efloreſces in the air, and changes into a real ſulphate of lead. On account of this property, M. Monnet calls it *pyritous ore of lead.* Dr Withering ſays, there is in the iſle of Angleſey a great quantity of lead and iron mineralized together by the ſulphuric acid.

4. Lead ore appears to be combined with the arſenic acid in the red lead ore of Siberia; which was firſt deſcribed by M. Lehman in the year 1766. This ore is of a very fine red colour, and its duſt reſembles carmine powder. It is often cryſtallized in rhomboidal tetrahædral priſms, which are ſhort and obliquely truncated. M. Mongez, who thinks arſenic to be in the ſtate of acid in all red ores, has diſcovered another ore of a greeniſh yellow colour, which comes from Siberia, and like the laſt mentioned contains arſenic.

5. M. Gahn has recognized the exiſtence of the phoſphoric acid in a greeniſh lead ore: this ore is ſometimes, too, yellow and reddiſh; and on diſſolving it in the nitric acid, and precipitating the oxide of lead by the

the ſulphuric acid, the phoſphoric acid is obtained by evaporating the ſupernatant liquor. Meſſrs la Metherie and Tenant at Paris have confirmed Gahn's analyſis. M. de Laumont has written a memoir on native phoſphate of lead, which is very plenteous in Britanny.

6. Lead is oftenеſt found in combination with ſulphur: This ore bears the name of *galena*; in commerce it is alſo called *alquifoux*. This ſulphure of lead generally conſiſts of plates having nearly the colour and aſpect of lead, but more brilliant, and very brittle. There are a great many diſtinct varieties of galena; namely:

Varieties.

A. Cubic Galena. Its cubes are of various ſizes, and either inſulated or in groupes. It is alſo found in regular octohædrons. There is a variety of it which the Abbè Hauy calls a *cubic octohædron*. Its ſurface exhibits ſix ſquares, and eight equilateral triangles. Some mineralogiſts have called it a cube truncated at the angles.

B. Maſſy Galena. This is in maſſes without any regular configuration. It abounds at Sainte Marie.

C. Galena with large facets. It appears not to form regular cryſtals, but is entirely compoſed of large plates.

D. Galena with ſmall facets. This galena appears to conſiſt like mica of ſmall and very bright white ſcales. It is called *white ſilver ore*, on account of its containing a large proportion of that metal. Of this kind is the galena of the mines of Pompéan in Brittany.

E. Galena with ſmall grains, ſo called becauſe its grains are very cloſe: this ore is likewiſe very

Varieties.

rich in ſilver, and is found along with the laſt mentioned ore. Galenas in general contain ſilver: We know of none which does not contain ſilver but the galena of Carinthia. But it has been obſerved, that the galena with the ſmalleſt facets and cloſeſt grains affords moſt ſilver. It would appear, that ſilver being in ſome manner unfit for entering into the combination of galena, of conſequence deranges the regularity of its cryſtallization when it happens to enter into it.

F. Galena cryſtallized like ſparry lead in hexagonal priſms, or cylindric columns. It is found, as well as the laſt mentioned ore, in the mines of Huelgoet in Low Brittany. It is not rich in ſilver, and appears to be only ſpathoſe lead mineralized without having loſt its form. In fact we ſometimes obſerve in the ſame piece cryſtals of pure ſparry lead entirely covered with very fine galena, and others entirely changed into galena through the interior parts of the priſms. M. Romé de Lille is in poſſeſſion of a number of ſuch ſpecimens. I have in my own cabinet a ſpecimen of white lead ore, the baſe of whoſe priſms is abſolutely in the ſtate of galena, and which diſplays the change of which I am ſpeaking.

Galena is generally found between two borders of blackiſh ochraceous quartz containing a good deal of ſilver, though that metal be not at the firſt obſervable. M. de Dolomieu, to whom we owe the obſervation of this

this fact, conjectures, that the lead might be at firſt mixed with this ſilver; and that the water carrying off the imperfect metal left the finer metal in the gangue. M. Monnot has diſcovered, that many galenas efflores like pyrites. He tells us, that he obtained true ſulphate of lead by waſhing one of thoſe ores, the ſurface of which was white, and bore the appearance of an efflorescence.

7. Lead is ſometimes combined in nature with ſulphur, antimony, and ſilver. This ore is called *antimoniated galena*, and is of a needled ſtriated ſtructure like antimony: the preſence of the ſemi-metal is known by the aſcenſion of a white ſublimate when the ore is calcined. It is found at Salberg and Sainte-Marie-aux-Mines.

8. There is another ſort of galena, in which the lead is combined with ſulphur, ſilver, and iron. This martial galena is harder and more ſolid than any of the foregoing. When ſcorified it affords yellow lead.

9. Laſtly, Lead is often met with in oxide and galena mixed in ſandy or calcareous earths and ſtones.

As almoſt all lead ores, and eſpecially galenas, contain a conſiderable proportion of ſilver, it requires to be carefully aſſayed. For this purpoſe, after pounding and waſhing a certain quantity of the ore, it is carefully put in a pot, which muſt be covered to prevent it from flying out. Galena ſuffers little loſs by roaſting. After having undergone this operation, it is weighed and melted with three times its own weight of black flux, and a little decrepitated marine ſalt. The fixed alkali of the black flux abſorbs the ſulphur from the lead: the coal of tartar, which is another part of the ſame flux,

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ſerves to reduce the metal from the ſtate of oxide, and the marine ſalt prevents the evaporation of a part of the metal contained in the crucible. After the melting a button of lead is found in the crucible, and muſt be carefully weighed. The metallic button is in the next place *calcined*, and vitrified on a cupel, to ſeparate the ſilver which it contains. The reſult of this aſſay is not entirely to be truſted to; for the alkali uſed as a flux forms with the ſulphur of the galena *liver of ſulphur*, or ſulphure, which diſſolves a portion of the lead. Beſides, black flux is too expenſive a reductive matter to be uſed in labours of this kind in the great way. It may therefore be proper to attempt the fuſion of this ore on coals, in a reverberating furnace, either by itſelf, or with an addition of ſome cheap matters, ſuch as iron and glaſs-gall, in a ſmall proportion, to abſorb the ſulphur.

Bergman propoſes the uſe of the nitric acid for aſſaying lead ores. That acid diſſolves lead and oxide of iron, but produces no effect on ſulphur. The ſolution is precipitated by carbonate of ſoda; and 132 grains of this precipitate are equal to 100 grains of lead in a metallic ſtate. When the ore happens to contain ſilver, the oxide of ſilver is ſeparated by ammoniac, which has the power of diſſolving it.

At Pompéan, in working lead ore containing ſilver, after pounding it, and waſhing it with great care on tables, they carry it to the furnace, where they firſt roaſt it with a moderate heat, and afterwards melt it by increaſing the fire. The melted lead is taken out of the furnace by a hole, which correſponds to one ſide of the hearth, and is ſtopped with clay during the operation.

ration. The lead is moulded into pigs; and now acquires the name of *wrought lead.* It contains ſilver. To ſeparate the ſilver, the wrought lead is put into another furnace, the hearth of which is covered with aſhes that have been lixiviated, ſifted, and preſſed down upon it. On one ſide of the hearth of this furnace there are two large bellows, and oppoſite to them two gutters, called *the paſſages of the litharge.* When the furnace becomes hot, the lead is oxidated; a part of it is evaporated and ſublimated in ſmall chimnies over the paſſages of the litharge: another portion of the metal is abſorbed by the floor of the furnace; a third, and that the moſt conſiderable portion, is oxidated and partly vitrified; and this laſt portion receives the name of *litharge.* It is blown out of the furnace with the bellows; the action of which likewiſe contributes to the oxidation and vitrification of the lead, by pouring a copious ſtream of air on the metal when in fuſion. When litharge has been calcined by a moderate fire, it is in a red ſcaly powder; it is then called *merchant's litharge*, becauſe it is ſold in this ſtate, or *golden litharge*, on account of its colour. If it has been expoſed to a ſtronger heat, it is then nearer a ſtate of vitrification, and of a pale colour: and it now bears the name of *ſilver litharge.* Laſtly, If the furnace be made very hot, the litharge is more completely melted, and runs into the form of irregular ſtalactites; it is now called *freſh litharge.* When the operation is finiſhed, the ſilver which was contained in the lead remains in the former. This ſilver muſt be refined in ſmall pieces, in order that it may throw off the lead which ſtill remains among its particles.

Lead,

Lead, after being oxidated in the refining, is again melted on coals, after which it contains but a very few particles of ſilver. It is now run into pigs and ſold in this form. Sparry lead is melted among coals in the ſame way as the oxides.

When lead is expoſed to fire, it melts long before becoming red hot. The heat requiſite to maintain it in fuſion is ſo ſlight, that a perſon may put his hand into melted lead without feeling any pain; and in that ſtate it does not burn vegetable ſubſtances. It is ſcarce volatile; yet a very ſtrong heat *will* volatilize it; and it then gives out ſmoke, and is reduced to vapour like the more fixed metals. If it be left to cool very ſlowly when melted, and if after a part becomes ſolid, what ſtill remains fluid be decanted off; the ſolid part is found cryſtallized in quadrangular pyramids, the form of which we have already deſcribed.

Lead expoſed to the contact of air while it melts, is covered with a grey duſky pellicle. This pellicle is carefully taken off, and reduced by agitation into a greeniſh grey powder, inclining to yellow. When this oxide is ſeparated by a ſieve from the grains of lead which are ſtill intermixed with it, and again expoſed to a more intenſe heat ſufficient to make it red hot, it aſſumes a deep yellow colour. In this ſtate it is called *maſſicot*. *Maſſicot*, ſlowly heated by a moderate fire, takes a beautiful red colour, and obtains the name of *minium*. If expoſed to a ſtrong heat, *maſſicot* melts into a glaſs, and does not afford any minium.

Lead, by being oxidated, gains an increaſe of weight nearly in the proportion of ten pounds to the hundred weight. This increaſe of weight which lead

gains when reduced to oxide, and the circumſtance of air's being neceſſary to this operation, led John Rey, a phyſician at Perigord, to conjecture, that air became fixed in this metal when it was *calcined*. Dr Prieſtly has confirmed John Rey's opinion by extracting vital air from minium. Oxide of Lead, though very high coloured, may be entirely diveſted of its colour. Minium, if rather too much heated, becomes pale: when urged with fire, without having any other ſubſtance intermixed, it melts into a tranſparent glaſs, ſo fuſible as to penetrate and make its way through all crucibles, notwithſtanding whatever can be done to retain it. But a mixture of one part of ſand with three parts of oxide of lead melts into a beautiful amber-coloured glaſs, the oxide contributing to the fuſion of the ſand. The tincture of that glaſs is fainter, and reſembles the colour of topaz, when two parts of oxide of lead and one of ſand or pulverized flint are melted together. A ſmaller quantity of oxide of lead added to common glaſs does not alter its tranſparency, but increaſes its ſpecific gravity, and gives it a kind of unctuouſneſs, which renders it eaſier to be cut and poliſhed without breaking. This glaſs is the moſt proper for making achromatic lenſes, but is very liable to be ſtriated, and gelatinous in its appearance. The Engliſh call it *flint glaſs*. Our merchants have no ſmall difficulty to find any large pieces without ſtriæ in that which they import from England. This, which is a very conſiderable inconvenience, ariſes, as Macquer thinks, from the circumſtance of the principles of the glaſs not combining uniformly together. To make them combine uniformly, it would be neceſſary to keep them long in fuſion; but

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as the lead is volatilized, the flint glass then loses part of its density, as well as that unctuousness which constitutes its peculiar value.

Although all the phænomena which attend the oxidation and vitrification of lead, show that it combines with the greatest facility, and in a very rapid manner with the base of pure air, or oxigene; yet it is among those metallic matters which have the least tendency to remain in combination with the oxigenous principle; for, as has been proved by Dr Priestley, it may be separated from it by the action of fire only. When minium is exposed to an intense heat in a retort, vital air is obtained from it, and a part of it is reduced to lead. All the oxides, and even glasses of lead, are easily decomposable by combustible matters: all that is necessary for this purpose is to mix them with charcoal, tallow, oils, resin, or in short any inflammable vegetable or animal substance; and to heat them till they afford a button of lead. This metal has therefore a weaker affinity than most other metallic substances with oxigene; and if it agrees with tin in some properties, in its oxidation and reduction it is subject to very different laws. These phænomena afford a new proof in favour of what we have advanced as one of the laws of the affinity of composition; namely, that we are not to judge of the affinity subsisting between any two bodies by the facility with which they combine, but rather by the obstinacy with which they adhere together.

All the oxides of lead, and more especially minium, absorb a certain quantity of carbonic acid when exposed to the air. And in order therefore to preserve

oxide of lead pure, it muſt be kept from the contact of air; or the carbonic acid, which it has abſorbed from the air, may be ſeparated by heating it before it be applied to any uſe.

Lead, when expoſed to the air, is tarniſhed; and the more moiſt the air, the ſooner does it produce this effect on the metal. A white duſt is formed, and gradually carried off by the water; that white duſt is not pure oxide of lead, but oxide of lead combined with carbonic acid abſorbed from the atmoſphere. The ſilver which is extracted from old lead that has been long expoſed to the air, is produced in conſequence of the lead not having been refined when it was firſt employed, and being in part oxidated by the action of the air of the atmoſphere. The ſilver not having been ſeparated from it at the firſt, has remained unaltered, and has even gradually increaſed in quantity as the imperfect metal has been deſtroyed by time.

Lead ſuffers no alteration from pure water; the metal does not ſeparate the component principles of the fluid; yet the ſides of leaden water-pipes are covered over with a whitiſh cruſt, or a kind of *ceruſe*, the production of which is owing, no doubt, to the action of the various matters contained in the water upon the metallic ſubſtance. M. Luzuriaga ſays, that on ſhaking lead in grains, in a little water, in contact with air, the metal is ſpeedily reduced to an oxide.

We know nothing of the action of ſalino-terrene ſubſtances and cauſtic alkalis on lead or its oxides.

This metal is ſoluble in all the acids. The concentrated ſulphuric acid acts upon it only when boiling; and

and it is likewiſe requiſite that the lead be in thin plates. Sulphureous gas eſcapes during the re-action of the metal and the acid. When the acid is moſtly decompoſed, the mixture becomes white and dry; when waſhed with diſtilled water it ſeparates into two portions. The moſt conſiderable of the two is inſoluble in water: it conſiſts of oxide of lead formed by the oxigene that the metal attracts from the ſulphuric acid, which has at the ſame time given out a good deal of ſulphureous gas. This oxide may be melted or reduced in the ſame way as that produced by the joint action of fire and air. The other portion, diſſolved by the water, is a combination of the ſulphuric acid with oxide of lead: this ſolution affords, when evaporated, ſmall needles of ſulphate of lead. M. Baumé and Bucquet have not deſcribed this ſalt as ſubſiſting in any other form but this. M. Monnet has ſometimes obtained it in ſhort priſmatic columns. M. Sage nearly agrees with M. Monnet, for he tells us, that ſulphate of lead affords cryſtals in tetrahædral priſms. This ſalt is very cauſtic, at leaſt 18 parts of water are requiſite to diſſolve it; it is decompoſed by fire, lime, or alkalis.

The nitric acid appears to act very ſtrongly on lead. When the acid is highly concentrated, and in no great quantity, the lead is ſpeedily reduced to a white oxide with the oxigene, which is diſengaged from the nitric acid at the ſame time when nitrous gas is diſengaged. But if the acid is weaker and in greater quantity, leſs of it is decompoſed, and there remains enough to diſſolve the oxide of lead. As the ſolution is effected,

there is a grey powder precipitated, which M. Groſſe took for mercury; but M. Baumé affirms it to be oxide of lead. I have many times, but ſtill ineffectually, attempted to obtain mercury from it by ſublimation, as alſo by urging it with fire ſufficiently intenſe to reduce it to mercury if it were mercurial oxide. This ſolution gives no precipitate with water; by cooling, it affords cryſtals of a dead white colour, in a flat triangular form, with all their angles truncated. The ſame ſolution ſubjected for ſeveral months to a ſlow evaporation, afforded cryſtals, the largeſt of which were about an inch in breadth, and their figure an hexahædral pyramid with three ſides, alternately ſmall and large, and its point truncated in ſuch a manner as to render it a ſolid octagon. Rouelle has given a good deſcription of this ſalt. Nitrate of lead decrepitates when expoſed to fire, and melts with a yellowiſh flame when laid on a burning coal; the oxide of lead, which is at firſt yellow, is very ſpeedily reduced to globules of lead. This ſalt is decompoſable by lime and alkalis. The ſulphuric acid, though it acts but very weakly on lead, has, however, a greater affinity than the nitric acid with the oxide of this metal. Pure ſulphuric acid, or even an earthy or alkaline ſulphate, poured into a nitric ſolution of lead, produces in a few moments a white precipitate. This precipitation takes place, becauſe the ſulphuric acid attracting the oxide of lead from the nitric acid, forms ſulphate of lead, not very ſoluble, and ſimilar to that which is prepared by an immediate combination of the ſulphuric acid with this metal.

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The pure muriatic acid, with the aſſiſtance of heat, is capable of oxidating lead, and diſſolves a part of the oxide; but it is not eaſy to ſaturate it completely. This ſolution contains always an exceſs of the acid: by a ſtrong evaporation, however, it affords fine, bright needled cryſtals, as has been obſerved by M. Monnet Muriate of lead is ſomewhat, though but very little, liable to deliquiate. Lime and alkalis diſſolve this, as well as the foregoing ſalts. This metal may be more readily and more intimately combined with the muriatic acid, by pouring the acid either free or combined with an alkaline or earthy baſe into a ſolution of nitrate of lead: A white precipitate, much more copious than that formed by the ſulphuric acid, and reſembling a coagulum, is inſtantly produced. This precipitate is a combination of oxide of lead with the muriatic acid, which has ſeparated the metallic oxide from the nitric acid. This ſalt ſubſides to the bottom of the liquor, becauſe it is much leſs ſoluble in water than nitrate of lead. If expoſed to fire, it gives out vapours, and melts into a brown maſs, called *corneous lead*, on account of the reſemblance it bears to the ſilver which is diſtinguiſhed by the ſame epithet. It diſſolves well enough in thirty times its weight of boiling water. The ſolution of this ſalt when evaporated, cryſtallizes into ſmall ſlender brilliant needles bundled together, or joined at one end under an obtuſe angle. M. Sage ſays, this ſolution gives by very ſlow evaporation cryſtals in ſtriated hexahædral priſms. The ſolution of corneous lead is decompoſable by the ſulphuric acid, which cauſes it to yield, like the nitric ſolution of lead, a white precipitate.

This diſcovery was made by Groſſe, and has been confirmed by M. Baumé, and all other chemiſts who have repeated the experiment. It contradicts the eighth column of Geoffroy's table, which repreſents lead as having a greater affinity with the muriatic than with any of the other mineral acids.

All ſolutions of lead yield either black or brown precipitates when expoſed to the action of earthy or alkaline ſulphures; and the ſulphure then unites with the oxide of lead to form a ſort of galena: a circumſtance which ſeems to indicate, that the lead exiſts in this ore in the ſtate of oxide. In theſe operations there is a double decompoſition, though not a double elective attraction; for the alkaline baſe of the ſulphure is alone ſufficient to decompoſe ſulphate, nitrate, and muriate lead.

All the oxides of lead are as eaſily decompoſed in acids as lead itſelf; nay, often eaſier than the metal. In theſe ſolutions minium loſes its colour. Lead does not act on ſulphuric neutral ſalts, nor does it decompoſe ſulphate of potaſh by heat, as tin, zinc, and antimony do.

Lead gives no ſenſible detonation with nitre. When the neutral ſalt is reduced to powder, and ſo caſt on the metal in a ſtate of fuſion and a little red, ſcarce any motion of the matters, and no diſcernible flame, follows. However, the lead is oxidated and vitrified by the alkali of the nitre, and is found after the operation in ſmall yellowiſh leaves like *litharge*.

Lead, with the help of heat, decompoſes ammoniacal muriate very readily. This property is common to it with many other metals. Any oxide of lead tri-

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turated cold with this ſalt, makes it give out ammoniacal gas. But, when this mixture is heated in a retort, the decompoſition is very rapid. The ammoniac obtained, in conſequence, is very cauſtic and poignant. Some chemiſts have advanced, that volatile alkali extracted by *minium*, effervelces with acids, and have inferred that *minium* muſt therefore contain carbonic acid. Bucquet obſerved, that this effervelcence was often owing to a portion of the ammoniac gas volatilized by the heat produced by the combination of the alkali with the acid; and that it did not take place when the acids employed were concentrated He made one ingenious and very deciſive experiment to determine this. Introducing into a bell glaſs, over mercury, ammoniac obtained by *minium*, he conveyed into it a portion of ſulphuric acid pretty ſtrong, and ſufficient to ſaturate the alkalis. At the inſtant when the two ſubſtances were mixed, an ebullition was produced, and a quantity of gas diſengaged, and again rapidly abſorbed, which was nothing but ammoniac gas. However, ſince it is acknowledged that oxides of lead, and particularly red lead or *minium*, contain carbonic acid, in conſequence of having abſorbed it from the atmoſphere, it will be granted, that the ammoniac diſengaged by thoſe oxides muſt acquire a part of it. The maſs remaining in the retort, after the decompoſition of ſal ammoniac by *minium*, is muriate of lead, which melts by a moderate heat into corneous lead, and may be totally diſſolved in water. This is the melted maſs which Margraff made uſe of in compoſing phoſphorus of urine.

Hydrogenous

Hydrogenous gas alters lead in a very ſenſible manner; it colours its ſurface, and communicates to it changeable clouds, of the ſhades of the rainbow; it reduces oxide of lead. Mimium, when brought into contact with this gas, becomes black, and takes the appearance of lead. Dr Prieſtly has obſerved, that a glaſs tube containing hydrogenous gas, and hermetically ſealed, on being expoſed for a number of days to the heat of a ſand-bath, becomes black within like foot, and a vacuum is at the ſame time formed, and drops of water are produced in the tube. This beautiful phænomenon is explained by conſidering that hydrogene has a greater affinity than lead with oxigene; a farther proof of which is, that this metal does not act at all upon water. Engliſh glaſs contains a good deal of oxide of lead: Hydrogenous gas, re-acting upon that oxide, gradually abſtracts from it the oxigene which it contains, and combines with it to form water, while the lead regains its metallic colour.

Sulphur eaſily unites with this metal. When theſe two ſubſtances are melted together, the product is a ſort of brittle mineral with facets, and of a deep grey ſparkling colour. Sulphure of lead is very like *galena*, and is much more difficult to melt than lead. This phænomenon is peculiar to the combinations of the metals with ſulphur. Very fuſible metals become difficult to melt when mixed with ſulphur; while again, ſuch metals are as difficult to melt, become very fuſible when united with this combuſtible matter.

We know nothing of the mixture of lead with arſenic. Neither nickel, manganeſe, cobalt, nor zinc combine

combines with this metal by fuſion. Antimony forms a brittle mixture with lead, with ſmall brilliant facets, in colour and contexture reſembling iron or ſteel, according to the proportions in which the principles of the mixture are combined together; the ſpecific gravity of this compound is greater than that of the two metallic ſubſtances taken ſeparately.

Lead unites with biſmuth, and forms by this combination a mixed metal of a fine cloſe grain, and very brittle. Mercury diſſolves lead with the greateſt facility. This amalgam is made up by pouring hot mercury into melted lead. It is white and ſparkling, and in a certain ſpace of time becomes ſolid: when triturated with amalgam of biſmuth, it becomes as fluid as running mercury. It is a circumſtance worthy of our notice, that this ſingular phænomenon takes place in the union of three metallic matters, which are very fuſible, very ponderous, and more or leſs volatile.

Lead combines readily with tin by fuſion. Two parts of lead and one of tin form a mixture more fuſible than either of the two metals ſeparate, and conſtitute the ſolder uſed by plumbers. Eight parts of biſmuth, five of lead, and three of tin, form a mixture which is ſo fuſible, that the heat of boiling water is ſufficient to melt it, as M. d'Arcet has diſcovered.

As a mixture of lead and tin is applied to many ordinary and domeſtic uſes; and as the firſt of theſe metals is capable of communicating ſome very noxious qualities to the utenſils formed of the ſecond, which are uſed in the kitchen and in the laboratory;

tory; it is of importance to know how to aſcertain the proportion of the lead in thoſe veſſels, for it is often above what the regulations of government allow. Meſſrs Bayen and Charlard have given a very good proceſs for determining what quantity of this dangerous metal may be contained in any given quantity of tin. It conſiſts in diſſolving two ounces of the tin in five ounces of very pure nitric acid, waſhing the oxide of tin thus obtained in four pounds of diſtilled water, and evaporating the water on a balneum-mariæ. This evaporation affords nitrate of lead, which muſt be calcined; and the reſidue is weighed as the quantity of lead contained in the two ounces of tin; allowing ſome grains for the additional weight which it muſt have acquired by oxidation, as well as for the other metallic ſubſtances, ſuch as zinc and copper, which may poſſibly be contained in the tin. Thoſe chemiſts thus aſcertained, that fine wrought tin contains about ten pounds of lead in the hundred weight; and that again, that which is ſold as common tin, contains generally twenty-five pounds of lead to the hundred weight. This is an enormous proportion of lead, and thoſe who uſe veſſels of common tin are certainly expoſed to no ſmall danger. It is almoſt continually met with in thoſe veſſels which are very much in common uſe; ſuch as meaſures for diſtributing fluids, particularly wine. It is eaſy to ſee, that a liquor which becomes ſo quickly ſour, muſt combine with the lead, and convey into the viſcera of the poor wretches compelled by neceſſity to drink it, the ſeeds of diſeaſe, which becomes the more afflicting

afflictive and fatal becauſe its cauſe is often unknown. Pewterers have ſeveral ways of aſcertaining the fineneſs of tin and the quantity of the lead which it contains. Bare inſpection is often ſufficient to them; and when this is not ſufficient, the weight and the ſound of the metal are all that they require farther in order to judge of it. They have two methods of aſſaying. The one called *the aſſay by the ſtone*, is performed by running the melted tin into an hemiſpheric cavity, cut in a thunder-ſtone, and terminating in a gutter. The appearances which the tin exhibits as it cools, its colour, the roundneſs of its ſurface, the depreſſion of the middle part of its ſurface, the ſound which proceeds from that part of the metal contained in the gutter when twilled backwards and forwards, are ſo many marks which the ſkilful workman carefully obſerves, and by which, from long habits of obſervation, he is enabled to determine exactly the quality of the metal under examination. However this be, the mode of aſſay employed by the Pariſian pewterers, does not appear to be ſo accurate as that uſed by the pewterers in the other parts of the kingdom. This ſecond aſſay is called the aſſay *by the ball*, or *by the medal*; becauſe it conſiſts in running the tin to be aſſayed in a mould which gives it the form either of a ball or of a flat maſs, in form like a medal. The weight of this moulded ſpecimen is then compared with a piece of fine tin, of equal bulk, run into the ſame mould. The more the tin examined exceeds in weight the ſpecimen of fine tin, the greater is the quantity of the lead with which it is alloyed. Meſſrs Bayen and Charlard, with good reaſon, prefer the latter

ter of theſe modes of aſſaying, as its principles are ſurer and leſs liable to fallacy, than thoſe circumſtances on which the workman determines in the aſſay of the ſtone.

Lead is applied to a great many purpoſes. It enters into many mixtures; pipes for conveying water are formed of it. Its oxides are uſed in making glaſs and preparing enamels. It is uſed to imitate the colour of yellow precious ſtones, and to render fuſible the matters uſed for glazing earthen ware. Veſſels and other utenſils for many purpoſes in ordinary life are made of this metal, but the uſe of them is not without danger to the health. Water ſuffered to ſtand in leaden baſons or fountains, is liable to acquire noxious qualities from the lead. The vapour of this metal is dangerous to the workmen who melt it; and its duſt ſtill more ſo to thoſe who file or grate it down. This metal, by inſinuating itſelf into ſome corners of the ſtomach, and fixing there, occaſions the moſt painful colics, which are often attended with the vomiting of a green bile, and cauſe the belly to flatten, and contract the navel inwards. It has been obſerved, that antimonial emetics and purgatives are the happieſt medicines in ſuch caſes. Navier recommends various alkaline ſulphures for poiſoning by preparations of lead, as well as againſt the effects of arſenic and corroſive mercurial muriate. That phyſician praiſes alkaline ſulphure and ſulphureous waters, more eſpecially for their good effects in removing the palſy and tremulous motions, which uſually continue to affect patients after the painter's colic. The plain inference from theſe facts is, that we

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muſt ceaſe to employ preparations of lead internally, and make uſe of it only as an external medicine; and beſides, it ſhould not be uſed even externally but with all the precautions neceſſary when we employ a violent repercuſſive.

THE END OF VOLUME SECOND.

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